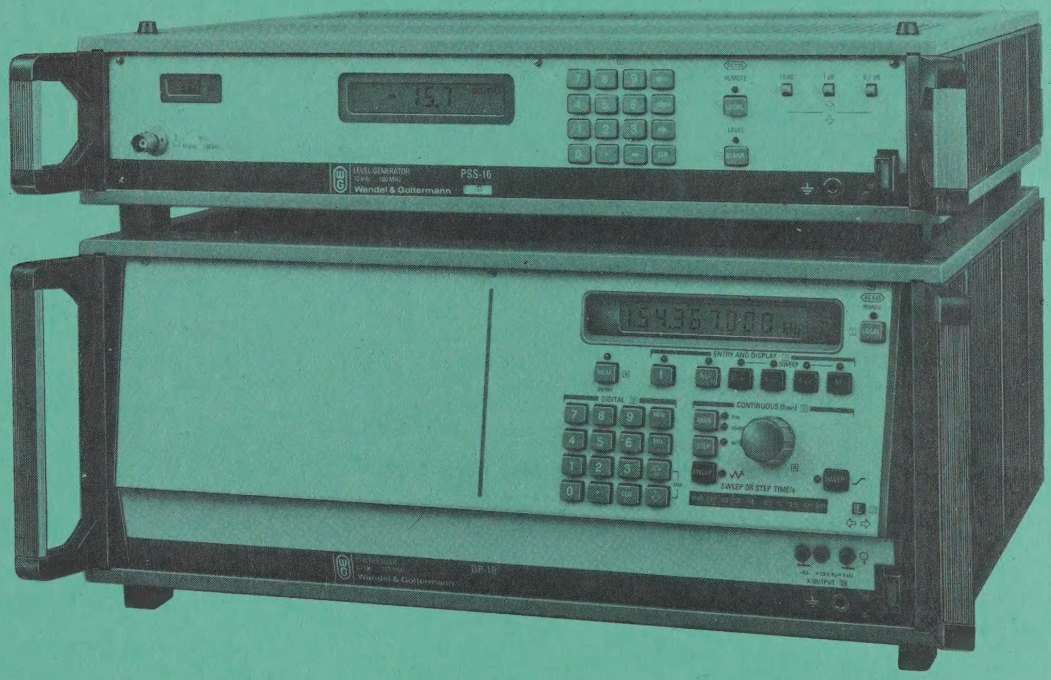
INSTRUMENT SHOP

Description and Operating Manual



Level Generator

PS-16

Frequency range 10 kHz to 160 MHz

Send Section PSS-16

BN 0873/00.82; Series A...

LEVEL GENERATOR PS-16
AND GENERATOR SECTION PSS-16

Frequency range 10 kHz to 160 MHz

Description and Operating Manual BN 872/873 A...

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Wandel & Goltermann

PRECISION ELECTRONIC
MEASURING INSTRUMENTS

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INTRODUCTION

The Level Generator PS-16 is a beat frequency generator which is characterized by its wide frequency range, its high frequency and level accuracy, and its ease of use. The use of modern integrated circuits and of a microcomputer provides a high degree of accuracy and ease of use.

The Level Generator PS-16, which consists of the Generator Section PSS-16 and the Synthesizer OP-16, is intended for the frequency range from 10 kHz to 160 MHz. Due to this wide frequency range, the PS-16 can be used in the development, production, installation, and maintenance of carrier frequency systems with up to 10,800 speech channels and also for measurements in single sideband radio relay links. A further application is measurements in submarine cable systems and examination of communications cables for digital transmission at high bit rates (140 MBit/s). Due to its remote control factilities, the Level Generator is also suitable for intergration in automatic measuring systems.

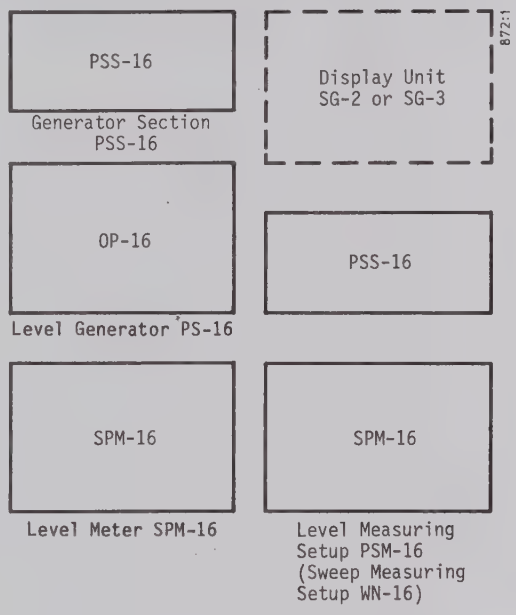


Fig. 1 "Type 16" equipment and measuring sets

Frequency generation is carried out in the Synthesizer OP-16. As required by the measuring task, the frequency of the PS-16 can be tuned digitally via a keyboard or continuously with a resolution of 1 Hz over the whole frequency range. For tuning to preset intervals, such as the space in-between channels, the frequency can be adjusted step by step, either manually or automatically. For frequently required measurements at fixed frequencies, up to 100 fixed frequencies can be stored via the keyboard and recalled either randomly or sequentially. In addition, if required, further fixed frequencies can be stored in a customer-specific read only memory. Regardless of the type of frequency tuning, the synthesizer achieves high stability and accuracy of the required frequency.

The output level can be adjusted digitally from the keyboard or step by step in minimum steps of 0.1 dB in the Generator Section PSS-16. Depending on the selected calibration, either the power level (dBm) or the voltage level (dB) is displayed. For measurements in transmission systems, it is also possible to set up the referred level (dBm0 or dB0) and the relative level (dBr) of the test point.

The output level is kept constant at the selected value by the internal AGC amplifier. In the case of longer connecting leads, attenuation and matching errors can be eliminated by connecting the control voltage of the Milliwatt Power Meter EPM-1, which can be used as control amplifier, to the control voltage input of the PSS-16. In this case, the Level Generator can also be used as a generator for a standard level of 0 dBm.

The output level can be blanked manually with a gradual transition in order to avoid interference with active systems. The Level Generator PS-16 can also be used as a sweep generator with no phase shifts in the output signal even during high speed sweep operations.

Depending on the application, either the two limit frequencies or the centre frequency and sweep width are entered digitally with quartz accuracy. Together with a Wideband Receiver (e.g. SGP-100), Discriminator (SGD-21), and Display Unit (SG-2 or SG-3), it is thus possible to check the equalization of carrier frequency transmission circuits.

In the case of loop measurements, the discriminator can be replaced by the X voltage output, which provides a deflection voltage for a plotter or display unit which is proportional to the sweep width.

The Level Generator PS-16 or the Generator Section PSS-16 can be combined with the Level Meter SPM-16 to form a complete level measuring set-up which permits loss and gain measurements. Whereas the combination of the PS-16 and SPM-16 permits measurements with differing send and receive frequencies, the combination of the PSS-16 with the SPM-16 offers a particularly economical configuation measurements with the same transmit and receive frequencies due to the use of a single synthesizer. If the measuring sets are supplemented with the Display Unit SG-2 or SG-3 and corresponding Display Unit adaptors, a sweep frequency measuring set for selective and wideband measurements can be formed (Figure 1).

Many measuring tasks are particularly easy to handle if the user stores equipment setups (frequency parameters) and recalls them when required. Depression of a single key (address call) causes the PS-16 to set up all previously selected measuring conditions for a specific task. In order to maintain the stored data in the case of mains failure or when the PS-16 is switched off, the supply voltage of the memories is buffered by a battery.

All main functions of the two instruments, PSS-16 and OP-16, can be controlled externally via an optional Interface Bus <IEC 625> board [1)]. With the aid of further equipment such as the Level Meter SPM-16, the Test Point Selector, or external memory systems, high performance, automatic measuring systems can be set up.

The models MU-7 or RAS-1 with interface board are suitable as Test Point Selectors up to 100 MHz.

For return loss measurements, the Bridge RFZ-14 is available (100 kHz to 100 MHz). For measurements in components and systems with an impedance of 50 Ω, 75 Ω/50 Ω adaptor circuits are available.

The Generator Section PSS-16 and the Synthesizer OP-16 are available as desktop units or as chassis for 19" racks. Front and rear covers can be fitted to protect the equipment against dust and splash water during storage or transport.

---

1) Connection to the IEEE Bus (IEEE 488) with an external adaptor plug

1 TECHNICAL DATA

All of the error limits established in the specifications are valid in the rated range of use of the influence quantities, unless otherwise stated, but after 15 minutes of warming-up time.

1.1 SYNTHESIZER OP-16

1.1.1 SEND FREQUENCY

Frequency range..... 10 kHz to 160 MHz

1.1.2 FREQUENCY DISPLAY..... 9 digits, LCD

Resolution..... 1 Hz

1.1.3 FREQUENCY SETTING

Digital with keyboard,
in frequency steps with direction keys, input of the step increment with keyboard,
quasi-continuously with knob over the complete frequency range,
switchable between coarse and fine tuning.

Smallest frequency step, digital..... 1 Hz
quasi-continuous, fine..... 1 Hz
coarse..... 100 Hz

1.1.4 AUTOMATIC FREQUENCY SEQUENCES

1.1.4.1 Auto Step

Automatic stepping of the tuned frequency in increments between current frequency limits.
Increments and frequency limits entered by keyboard
Stepping speed adjustable..... 0.03; 0.1; ...; 300 s

1.1.4.2 Sweep Mode

Sweep limits are set with the keyboard by entering either the start and stop frequency or the center frequency and the deviation.

Sweep sequence: periodic (triangular) or single sweep.
Sweep duration ($f_{start} \longrightarrow f_{stop}$), adjustable..... 0.03; 0.1; ...; 300 s
Additional facility..... manual sweep with knob

1.1.5 ERROR LIMITS OF FREQUENCY ..... $\pm 1 \cdot 10^{-7}$

The error limits specified here are valid for the nominal operating ranges of environment parameters specified in section 1.3, including aging over a period of one year.

1.1.6 ADDITIONAL INPUTS AND OUTPUTS

1.1.6.1 Synthesizer frequency output [44]

Connector ..... System Versacon ® 9
Frequency range ..... 10 kHz to 160 MHz
Level into 75 Ω load ..... typ. (-15 ±0.5)dBm

1.1.6.2 Input [45] and output [52] for control frequency

Connectors ..... System Versacon ® 9
Frequency range ..... 220 to 380 MHz
Level into 75 Ω load ..... (+3 ±2) dBm

1.1.6.3 Input for external standard frequency [51]

Connector ..... System Versacon ® 9
Frequencies ..... 1; 2; 5 or 10 MHz
Necessary level ..... -10 to +10 dBm
Input impedance ..... 75 Ω

1.1.6.4 Output for standard frequency [50]

Connector ..... System Versacon ® 9
Frequency ..... 10 MHz
Level into 75 Ω load ..... 0 dBm +2/-4 dBm

1.1.6.5 X-output (DC) [23]

DC output voltage proportional to frequency within the start and stop frequency limits.
Open circuit voltage at start frequency ..... -2.5 V
at stop frequency ..... +2.5 V
Output impedance ..... 5 kΩ

1.1.6.6 Interface Bus <IEC 625> for remote control

with auxiliary device BN 853/02.

All equipment functions can be remotely controlled by means of the Interface Bus <IEC 625> connector on the rear of the instrument.

Switching between manual and remote control by means of a pushbutton.

1.1.7 MEMORIES FOR FIXED FREQUENCIES AND INSTRUMENT SETTINGS

1.1.7.1 Number of fixed frequencies

freely programmable[1)] 100
permanently programmable (auxiliary device BN 872/00.01) 100
The fixed frequencies can be advanced automatically by one step per address step as described in section 1.1.4.1.

1.1.7.2 Number of equipment settings

freely programmable[1)] 10
permanently programmable (auxiliary device BN 872/00.01) 40

1.2 S E N D S E C T I O N P S S - 1 6

1.2.1 FREQUENCY RANGE ..... 10 kHz to 160 MHz

1.2.2 SIGNAL SHAPE ..... sinusoidal

1.2.3 LEVEL DISPLAY

- R.M.S. value, 3-digit LCD display with sign, resolution ..... 0.1 dB
- as power level (dBm) referred to ..... 1 mW
- as voltage level (dB) referred to ..... 0.7746 V
- as "related" level (dBm0, dB0) referred to a "relative" level (dBr) which can be selected anywhere within the overall level range (as specified in section 1.2.5).

The upper and lower limits of the algebraic sum of the related and relative levels correspond to the limits P_{min} and P_{max} of the level range (as specified in section 1.2.5).

1.2.4 LEVEL SETTING

on keypad, resolution ..... 0.1 dB
the level can be changed step-by-step with incrementation keys for each decade position, with automatic overflow.

1.2.5 LEVEL RANGE

Level range of the send level ..... -69.9 to +10 dBm (-69.9 to +1.0 dB)

---

1) Maintenance of stored data in the case of a.c. dropout ..... approx. 30 days

1.2.6 ERROR LIMITS OF THE SEND LEVEL

Limits of total error		
in level range	in frequency range 50 kHz to 100 MHz	in frequency range 10 kHz to 160 MHz
with 0 dBm (-9 dB)	± 0.05 dB	± 0.10 dB
for level > -20 dBm (-29 dB)	± 0.08 dB	± 0.15 dB
for level > -40 dBm (-49 dB)	± 0.12 dB	± 0.25 dB
for level > -70 dBm (-70 dB)	± 0.20 dB	± 0.35 dB

1.2.7 VARIATION WITH FREQUENCY

Limits of variation with frequency referred to 20 kHz		
in level range	in frequency range 50 kHz to 100 MHz	in frequency range 10 kHz to 160 MHz
with 0 dBm (-9 dB)	± 0.03 dB	± 0.08 dB
for level > -20 dBm (-29 dB)	± 0.06 dB	± 0.12 dB
for level > -40 dBm (-49 dB)	± 0.09 dB	± 0.18 dB
for level > -70 dBm (-70 dB)	± 0.15 dB	± 0.30 dB

1.2.8 MEASURING OUTPUT

coaxial, tied to ground, convertible to
all common connector types..... System Versacon® 9
Output impedance..... 75 Ω
Frequency range..... 10 kHz to 160 MHz

Return loss to.....	100 MHz	160 MHz
for level > 0 dBm (-9 dB).....	≥ 30 dB	≤ 20 dB
for level ≤ 0 dBm (-9 dB).....	≥ 34 dB	≥ 26 dB

1.2.9 SPECTRAL PURITY OF THE OUTPUT VOLTAGE

1.2.9.1 Harmonic ratio

Attenuation of harmonic spurious signals

for send frequency.....	100 MHz	160 MHz
for level ≤ +5 dBm (-4 dB).....	≥ 40 dB	≥ 34 dB
for level < +10 dBm (+1 dB).....	≥ 40 dB	≥ 32 dB

1.2.9.2 Non-harmonic ratio

Attenuation of discrete, non-harmonic spurious signals
at variable separation from the send frequency
for send and spurious frequencies < 110 MHz..... approx. 65 dB

Also valid in overall frequency range, except
the component at 220 MHz minus the
send frequency
Attenuation..... approx. 50 dB

Attenuation of discrete spurious components
at constant frequency separations > 30 Hz..... ≥ 60 dB
> 150 Hz..... ≥ 70 dB

1.2.9.3 Noise

Signal-to-noise ratio referred to a 1 Hz bandwidth at 0 dBm (-9 dB), in range 300 kHz to 160 MHz at a frequency offset from the utilized signal of:

≥ 300 Hz..... ≥ 75 dB
≥ 10 kHz..... ≥ 90 dB
≥ 20 kHz..... ≥ 100 dB
≥ 50 kHz..... ≥ 110 dB

1.2.10 GENERATOR BLANKING

manually through key, attenuation when blanked..... > 70 dB
The send level is switched on and off "softly".
The output impedance of the Generator remains unchanged.

1.2.11 ADDITIONAL OUTPUTS AND INPUTS

1.2.11.1 Signal frequency input [11]

For frequency tuning through Synthesizer OP-16 or Level Meter SPM-16
Connector..... System Versacon® 9
Necessary input level..... (-15 ± 0.5) dBm
Input impedance..... 75 Ω

1.2.11.2 Input for external automatic level control

Connector..... 3 pole CF connector
Controlling range..... approx. ± 1 dB
Control voltage..... approx. 1.3 V ± 0.7 V
Input impedance..... approx. 30 kΩ

1.2.11.3 Interface Bus <IEC 625> for remote control

with Auxiliary Device BN 873/00.01

All important equipment functions can be remotely controlled by means of the Interface Bus <IEC 625> connector on the rear of the instrument.

Switching between manual and remote control by means of a pushbutton.

1.3 POWER SUPPLY AND AMBIENT CONDITIONS

1.3.1 POWER SUPPLY

Rated range of use of a.c. power voltage..... 110/117/127/220/227/237 V -12% to +10%
Rated range of use of a.c. line frequency..... 47.5 to 63 Hz
Power consumption, OP-16..... approx. 90 VA
PSS-16..... approx. 30 VA

Safety class to IEC 348 and VDE 0411..... Class I

1.3.2 OPERATING CLIMATE

Tolerable ambient temperature
Rated range of use..... +5°C to +40°C
Limits range for storage and transport..... -40°C to +70°C

Radio frequency interference suppression in accordance with Vfg. 526/1979 issued by the Federal German Post Office

1.4 DIMENSIONS, WEIGHT

Synthesizer OP-16

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	199	Height (4 units)	175
Depth with handles	432	Depth	377

19" conversion kit..... BN 700/00.04
Weight..... 16 kg

Send Section PSS-16

Dimensions in mm

Bench model		19" Rack mounting (DIN 41 494)	
Width with handles	477	Width	443
Height overall	110	Height (2 units)	86
Depth with handles	425	Depth	370

19" conversion kit..... BN 700/00.02
Weight..... 10 kg

1.5 AUXILIARY DEVICES

1.5.1 PERMANENTLY STORED VALUES (EPROM)

BN 872/00.01

For the OP-16 Synthesizer

Storage of 100 fixed frequencies and 40 instrument settings (frequency parameters) in a non-volatile memory (EPROM), according to user's request.
(Ask for Ordering Form No. 5/797a, b)

1.5.2 INTERFACE BUS <IEC 625> CARD

BN 853/02 and BN 873/00.01[1)]

For controlling the OP-16 and PSS-16 through an external computer; connection to the IEEE-Bus through adaptor plug.

1.6 ACCESSORIES

1.6.1 MATCHING SECTION FEDA-1 (75 Ω/50 Ω)

The specifications are valid for the Matching Section without adaptor for ambient temperature of +23°C ± 5°C.

Impedances ..... 75 Ω/50 Ω
Frequency range ..... d.c. to 100 MHz
Image attenuation ..... 6 dB
Accuracy limits of attenuation ..... ± 0.1 dB
Return loss coefficient ..... ≤ 0.01
Capability for loading ..... ≤ 1 W
Maximum permissible ambient temperature with rated load ..... 0 to +45°C
Storage temperature ..... -55°C to +60°C

Connections
75 Ω side ..... 2.5/6 (F) or 1.6/10 (M/F) or BNC (M/F) or N connector (M/F)
50 Ω side ..... BNC (M/F) or N connector (M/F)

Abbreviations: (M) = plug connector,
(F) = jack connector

---

1) previous designation BN 906/02

1.7 ORDERING INFORMATION

Synthesizer OP-16	BN 872/01
Send Section PSS-16*	BN 873/01
Auxiliary devices (at extra cost):	
Permanently stored values (EPROM) for OP-16; for fixed frequencies and instrument settings[1)]	BN 872/00.01
Interface Bus <IEC 625> Card with adapter plug IEC 625/IEEE 488 (S 834)	
for OP-16	BN 853/02
for PSS-16	BN 873/00.01[3)]
Accessories (at extra cost):	
Matching Section FEDA-1, 75 Ω/50 Ω	BN 319/00
Milliwatt Power Meter EPM-1, 0; 10 Hz to 300 MHz[2)]	BN 564/00
Interconnecting cable for Interface Bus <IEC 625>	
120 cm long	K 343
200 cm long	K 344
Front and back panel covers	
for OP-16 (1 Set)	SD 4
for PSS-16 (1 Set)	SD 2
19" conversion kit	
for OP-16	BN 700/00.04
for PSS-16	BN 700/00.02
Transport Container TPK-4	
for OP-16	BN 626/10
Transport Case TPG-4	
for OP-16	BN 621/04
for PSS-16	BN 621/42

* Equipped with the 75 Ω basic connector Versacon® 9 and BNC adapter. For other adapter types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

1) State chosen fixed frequencies and instrument settings (frequency parameters) when ordering. (Ordering Form No. 5/797a, b).

2) See data sheet EPM-1 for ordering details and data.

3) Previous designation BN 906/02.

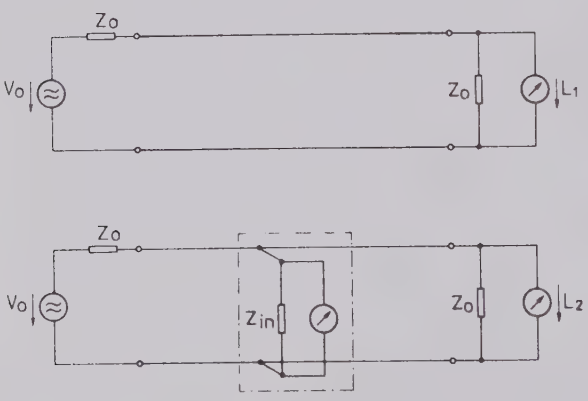
Return Loss

The effect introduced by the return loss of the receiver input or the generator output is included in the error specified for the level reading of a receiver or the output level of a generator.

Moreover, the specified error takes into account that a level meter is operated as "terminated" (input impedance = source impedance = Z_0). This is also valid for a level generator (output impedance = load impedance = Z_0).

Bridging Loss

A receiver operated in the "high impedance" (bridging) mode introduces a level error due to the finite input impedance. The error's maximum value when measured at a testpoint of source impedance Z/2 is expressed as a_B, the bridging loss.



The bridging loss is defined as follows:
Bridging loss $a_B = L_2 - L_1$

$$a_B = 20 \text{ lg} \left| 1 + \frac{1}{2} \frac{Z_0}{Z_{in}} \right|$$

Therefore, the bridging loss is the level difference caused by the high impedance level meter input bridging a system terminated with Z_0.

In every case, $Z_{in} \gg Z_0$, which results in:

$$a_B \leqq 4.3 \frac{Z_0}{Z_{in}} \quad [dB]$$

For that reason, the specified value of $a_{B,1}$ related to the value Z_1 (e.g. 600 Ohms) can be easily recalculated to yield the value of $a_{B,2}$ for the value Z_2 (e.g. 900 Ohms):

$$a_{B,2} = a_{B,1} \cdot \frac{Z_2}{Z_1}$$

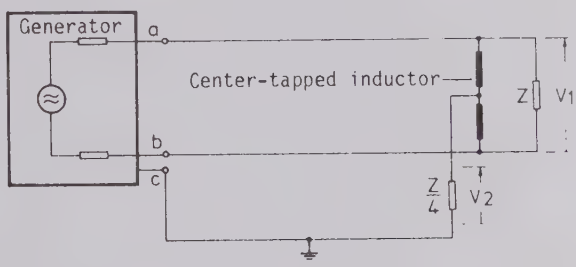
Impedance balance ratio

The specifications given for the input or output balance are provided by the methods defined in CCITT Recommendation O. 121.

This same Recommendation states that:
"The signal balance ratio is an overall measurement of the symmetry of a device and includes the influence of the impedance balance ratio as well as the influence of unwanted longitudinal voltages produced by a generator or the influence of the common-mode rejection ratio of a receiver."

To describe the degree of balance of a device (generator or receiver) under operational conditions in most cases it is sufficient to measure and specify the signal balance ratio only. Thus, the specifications in this Operating Mannual are provided by measurement of signal balance ratio. This is done through emplomont of an accurately center-tapped inductor with both of the tightly-coupled half windings being completely symmetrical. Each half represents Z/2.

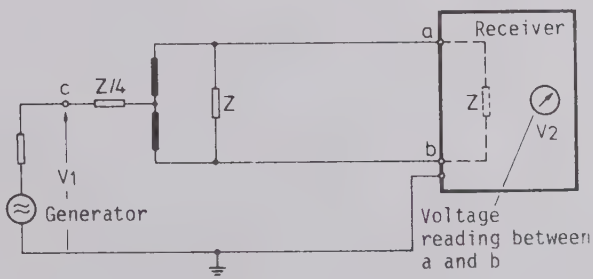
Measurement of Generator Signal Balance Ratio



Generator signal balance ratio is defined as:

$$a_B = 20 \log \left| \frac{V_1}{V_2} \right| \quad [dB]$$

Measurement of Receiver Signal Balance Ratio



Receiver signal balance ratio is defined as:

$$a_B = 20 \log \left| \frac{V_1}{V_2} \right| \quad [dB]$$

The dotted impedance, Z, is the input impedance of the device under test. If the input impedance is a high value, then this impedance must be externally connected in the parallel.

2 TECHNICAL DETAILS

The Level Generator PS-16 comprises, as shown in Figure 2-1, Generator Section PSS-16 and Synthesizer OP-16. If the Synthesizer is replaced by the Selective Level Meter SPM-16, the resulting combination of PSS-16 and SPM-16 is the Level Measuring Setup PSM-16.

Level and frequency generation are described in detail on the basis of the extremely simplified block diagram in Figure 2-1 in the following sections.

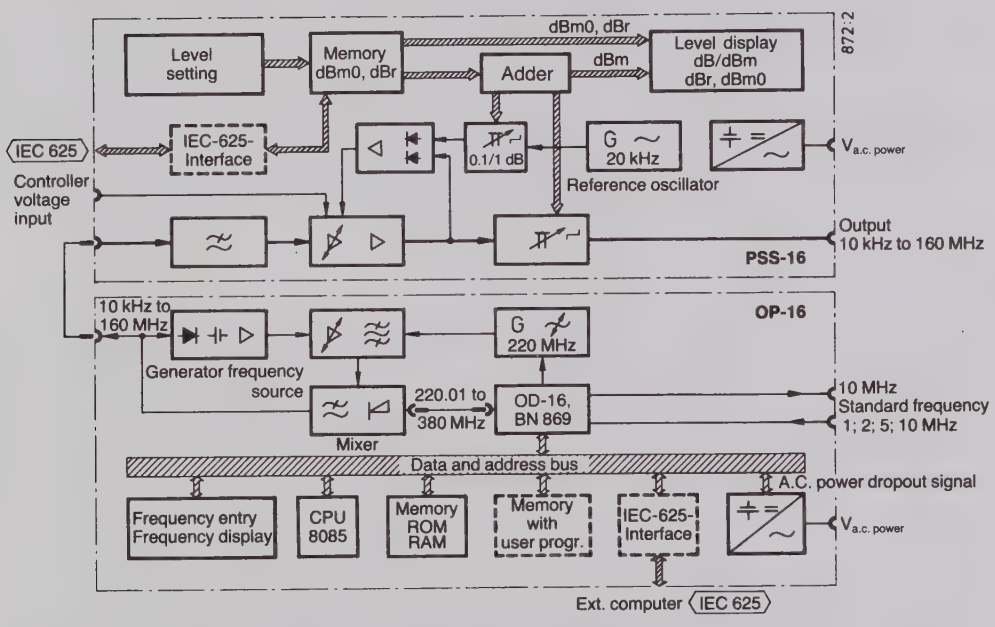


Figure 2-1 Simplified block diagram of the Level Generator PS-16

2.1 GENERATOR SECTION PSS-16

The Generator Section PSS-16 carries out level generation for the signal frequency of 10 kHz to 160 MHz supplied by the Synthesizer OP-16 or the Level Meter SPM-16. The main parts of the PSS-16 are the amplifier and attenuator assemblies (AGC amplifier), the control logic for level setting and display, and the power supply unit.

2.1.1 LEVEL GENERATION

The send frequency signal supplied by the OP-16 or SPM-16 (-15 dBm) is fed via a 160 MHz low-pass filter to an AGC amplifier (BN 9091/02), which keeps the output level of the amplified signal constant at the set value regardless of the frequency. The AGC voltage is obtained by comparing the output voltage with a 20 kHz reference voltage. The output level can be adjusted in steps of 10, 1 and 0.1 dB with precise, variable attenuators.

For external level control, e.g. with the Milliwatt Power Meter EPM-1, an external amplitude regulation circuit can be constructed via the control voltage input of the AGC amplifier.

The output level can be blanked and unblanked in the AGC amplifier by depression of a key, the operation being carried out with a gradual transition. In order to achieve a high blanking attenuation, the signal path is also interrupted before the low-pass filter.

2.1.2 LEVEL SETTING AND DISPLAY

A level entered on the keyboard is transferred to the memory and to the display for "dBr" or "dBm0" after depression of the entry key (dBm, dBm0, dBr). These two level values are added in an adder stage to form the absolute value of the level, the adder stage also switching the attenuators in the AGC amplifier. If an absolute voltage or power level is entered, the display "dBr" is switched off.

2.1.3 POWER SUPPLY UNIT

The Generator Section PSS-16 is equipped with a conventional power supply unit which can be set to all normal mains voltage values.

A built-in rechargeable battery supplies the two memories with voltage in the case of mains failure or if the PS-16 is switched off, thus ensuring that stored data and settings are retained.

2.1.4 REMOTE CONTROL

Frequency tuning is carried out digitally in BCD code in all operating modes. For pseudo-continuous tuning over a continuous range, a small DC generator (tacho-generator) generates switching pulses for the internal counters via a voltage-frequency converter. The frequency information is passed to the frequency display and the synthesizer via the display buffer.

2.2 S Y N T H E S I Z E R O P - 16

2.2.1 FREQUENCY GENERATION

Frequency generation for the Generator Section PSS-16 is carried out in the Synthesizer OP-16, which contains the Synthesizer sub-assembly OD-16 (BN 869), the microcomputer, and the control section for frequency setting and frequency sequences. The Synthesizer OP-16 generates the output frequency of the Level Generator using the beat frequency principle, by forming the difference between a fixed frequency (220 MHz) and a variable frequency (220.01 to 380 MHz) provided by the OD-16.

The synthesizer assembly is characterized by the following features:

- High frequency accuracy and stability
- High spectral purity (low spurious signals and high signal-to-noise ratio)
- Phase continuity during frequency changes
- High setting rate
- Compact construction.

The construction and the most important assemblies are shown in the extremely simplified block diagram of the OD-16 (Figure 2-2).

The control frequency f_T (220.01 to 380 MHz) is generated in a voltage controlled oscillator which is controlled such that the control frequency is precisely the sum of the frequencies f_R from the locking oscillator and f_I from the interpolation oscillator.

The locking oscillator works in the frequency range 219.8 to 379.7 MHz. It can be tuned in 100 kHz steps in a further control loop. For this purpose, the oscillator frequency is divided down to 100 kHz in a programmable locking divider and compared in a zero phase regulator with the standard frequency.

Interpolation between the 100 kHz steps of the locking oscillator is carried out in a single interpolation loop. This operates with non-integral division ratios, thus permitting tuning to frequencies with digits after the decimal point [1].

This arrangement results in short tuning times, even with small step increments.

The interpolation oscillator runs at relatively high frequencies between 40 and 60 MHz in order to permit reduction of phase interferance coming from the control loop in the following 200:1 divider.

As it is necessary to adjust the interpolation frequency in steps of 1 Hz, the interpolation divider must be adjusted in steps of 200 Hz, due to the following 200:1 divider. In order to permit rapid reprogramming, the output frequency of the interpolation divider is 100 kHz. This is compared with the divided standard frequency in the phase meter. Frequency settings in the 1 Hz to 1 kHz positions would result in phase interference due to the non-integral division. For this reason, a compensation voltage in the form of the interference voltage is inverted and overlaid on the output signal of the phase meter.

Further measures, such as synchronous transfer of the frequency tuning information into the locking and interpolation dividers, or blanking of the carrier loop in the case of the so-called interpolation exchange, result in low spurious signals in the control signal.

---

[1] P. Harzer: Frequenzsynthese in modernen Pegelmeßplätzen NTZ, Band 33 (1980), Heft 2, S.90-94 (Request Special Publication in English)

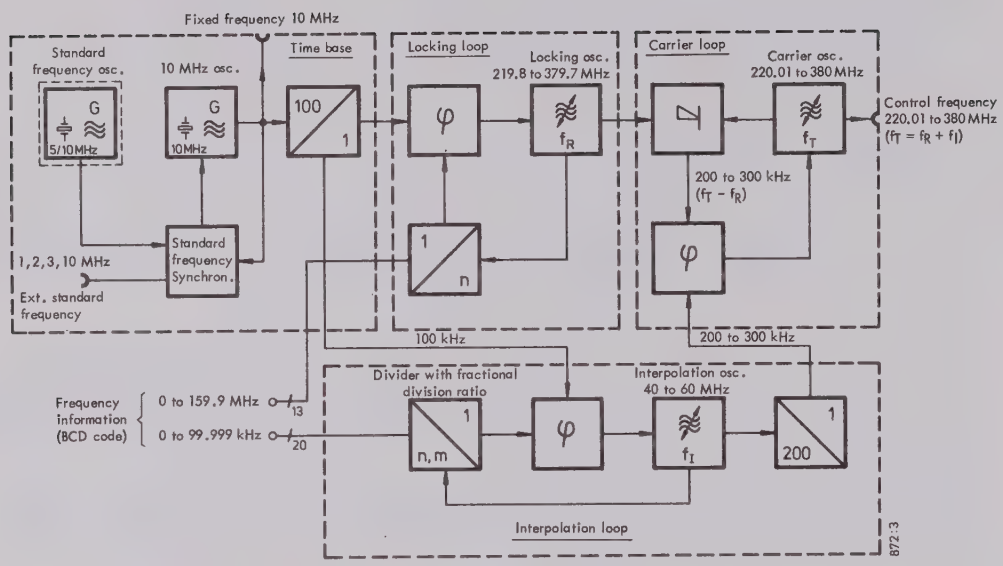


Figure 2-2 Simplified block diagram of the Synthesizer Module OD-16, BN 869

The 100 kHz reference frequency and further synchronization frequencies are generated in the time base. This consists mainly of the standard frequency oscillator and a 10 MHz quartz oscillator with very few harmonics which is phase locked to the reference frequency via the standard frequency synchronization. The standard frequency oscillator, which can also be replaced by external frequency standards of 1, 2, 5 or 10 MHz, is thermostatically controlled to obtain the required accuracy of 1×10^{-7}.

2.2.2 CONTROL SECTION WITH MICROCOMPUTER

The microcomputer comprises the central processing unit (CPU) - a microprocessor type 8085 - the program memory (ROM), the working memory (RAM), and the input and output ports. The display and the keyboards on the front panel are connected via data and control lines to the microcomputer. The keyboard is used, amongst other other things, for entry of fixed frequencies and complete equipment setups into the main memory.

If required, an additional, customer-specific read only memory (EPROM) for fixed frequencies and equipment setups can be installed.

When the PS-16 is switched on, an automatic RAM/ROM test is executed. In the case of an error, execution is stopped and the error number is displayed.

2.2.3 POWER SUPPLY UNIT

The Synthesizer OP-16 is equipped with an conventional power supply unit which can be set to all normal mains voltage values.

A built-in rechargeable battery supplies the RAM module with voltage in the case of mains failure or if the PS-16 is switched off, thus ensuring that stored data and setups are retained.

2.2.4 REMOTE CONTROL

For remote control the Synthesizer OP-16 by an external computer, the optional interface board for the <IEC 625> Bus can be fitted.

Important Safety Instructions

A.C. power line voltage

The operating voltage of the instrument should be the same as the a.c. line voltage, so check whether or not the two voltages are equal.

Safety Class

This instrument is categorized as Safety Class I according to VDE 0411 or IEC Publ. 348. The power cord delivered with the equipment has a protective ground conductor. The a.c. power plug must be plugged into an a.c. power receptacle that has a third wire to ground, except in rooms that are particularly certified otherwise. Any disconnection of the protective ground conductor either inside or outside of the instrument is not permitted.

Connection to measuring circuits presenting hazards to personnel

Before the connection is made to a hazardous circuit, a protective ground connection, for protection against the measurement circuit, ought to be connected to the enclosure. In case the protective ground conductor of the a.c. power line can also assume this protective function, the a.c. power connection should be established first of all. If the measuring circuit has an inherent protective ground conductor, then this conductor must be connected to the enclosure before a connection is made to the measuring circuit.

Defects and Exceptional Conditions

When it can be assumed that safe operation is no longer possible, the equipment should be taken out of service and inadvertent operation should be prevented.
This occurs when

- the equipment shows external signs of damage
- the equipment no longer operates
- after being overstressed in any way (e.g. storage, transport) so that the tolerable limits are exceeded.

Fuses

Only specified fuses are permitted for use.

Opening the Instrument

After the covers have been removed or when components are removed with tools, certain components that operate with applied voltage could be exposed. And also connection points might be carrying a voltage.
Therefore, before the instrument is opened for inspection, all voltage sources should be disconnected.
But sometimes calibration, maintenance or repairs require that the instrument be open and operating with applied voltage. So only experienced craftspersons who understand the dangers associated with working on instruments that have exposed voltage points should undertake the job.
Capacitors can retain a voltage charge even after the instrument has been disconnected from voltage sources. Thus, the circuit diagrams should be observed.

Repairs, Replacement of Components

Repairs must be done according to correct technical practice. With that, particular attention must be paid to the characteristics of construction. None of the safety precautions should be changed, especially for leakage paths and air gaps, and separation by insulation must not be reduced.
Only original replacement parts ought to be used. Other replacement parts are only permitted if the safety and protection against human injury are not degraded through the use of non-original components.

Safety Testing after Repair and Maintenance

Testing of the protective ground conductor in the power cord for the instrument:

The resistance of the protective ground conductor shall be measured. It should be $<0.5\ \Omega$. The power cord should be bent and kinked during the measurement so as to reveal any intermittent connection. This gives evidence of a defective power cord.

Testing the insulation of the a.c. power circuit:

The insulation resistance is measured at 500 V between the a.c. power connection and the protective ground conductor connection. For this measurement, the instrument's power switch should be ON.
The insulation resistance ought to be $>2\ M\Omega$.

3 PUTTING INTO SERVICE AND OPERATION

3.1 INTRODUCTORY NOTES

3.1.1 INSTALLING THE UNITS

The Synthesizer OP-16 and the Generator Section PSS-16 can be operated at ambient temperatures between +5 and +40° C. If used within larger systems or installed in racks, care must be taken that this temperature range is not exceeded (e.g. by providing sufficient space between the various units, see Chapter 5).

Temperatures between -40 and +70° C are permissible for storage or transport. In this case, it is recommended that the displays and controls are protected against mechanical damage, dust, and splash water by means of the Protective Transport Covers SD-4 for the OP-16 or SD-2 for the PSS-16 on the front and rear sides.

The PS-16 can be inclined slightly by swinging out the support mounted on the front feet of the instrument. This has no effect on reliable operation of the equipment.

The liquid crystal displays used for frequency (OP-16) and level (PSS-16) reduce the current requirements and the internal heating of the PS-16, which means that no ventilator is required and high reliability is achieved.

When installing the equipment, remember that the displays are easier to read in a good ambient light.

Code No. of control	Abbreviation in circuit diagrams	Function
[1]	3 Bu 4	Coaxial output, 10 kHz to 160 MHz
[2]	4 S 1 ... S 16	Numerical keypad for level entry
	4 S 13	CLR Clear key
[3]	4 S 17	LOCAL Key for switching to manual (local) mode during remote control
[4]	4 S 18	BLANK Manual level blanking
[5]	4 S 19	10 dB level adjustment with direction key
[6]	4 S 20	1 dB level adjustment with direction key
[7]	4 S 21	0.1 dB level adjustment with direction key
A	6 JC 201	Display of relative level (TLP) in dBr
B	6 JC 106	Digital display of level for input and after transfer to memory
C	1 Bu 1	Ground socket
D	1 S 1	Mains switch

Table 3-1 Controls and connectors on the front of the PSS-16 (see figure 3-1)

Code No. of control	Abbreviation in circuit diagrams	Function
[11]	3 Bu 1	Input for output frequency signal 10 kHz to 160 MHz from OP-16 or SPM-16
[12]	5 S 1	dB/dBm changeover switch
[13]	3 Bu 5	Input for external level control
E	1 Si 1	Mains fuse
F	8 (92)	Insertion position for Interface Bus <IEC 625> board
G	1 S 2	Mains voltage selection switch
H	1 St 1	Mains plug
J		Equipment data
K		Accessory box for spare fuses, assembly wrench, hexagon wrench
L		Mains cable clips

Table 3-2 Controls and connectors on the rear of the PSS-16 (see figure 3-2)

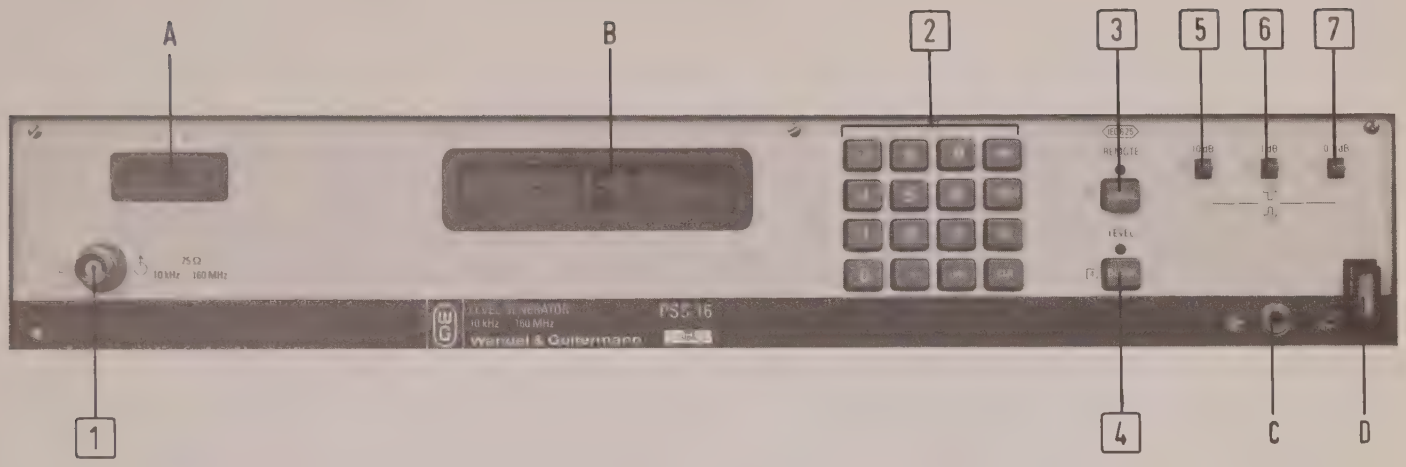


Figure 3-1 Front view of the PSS-16

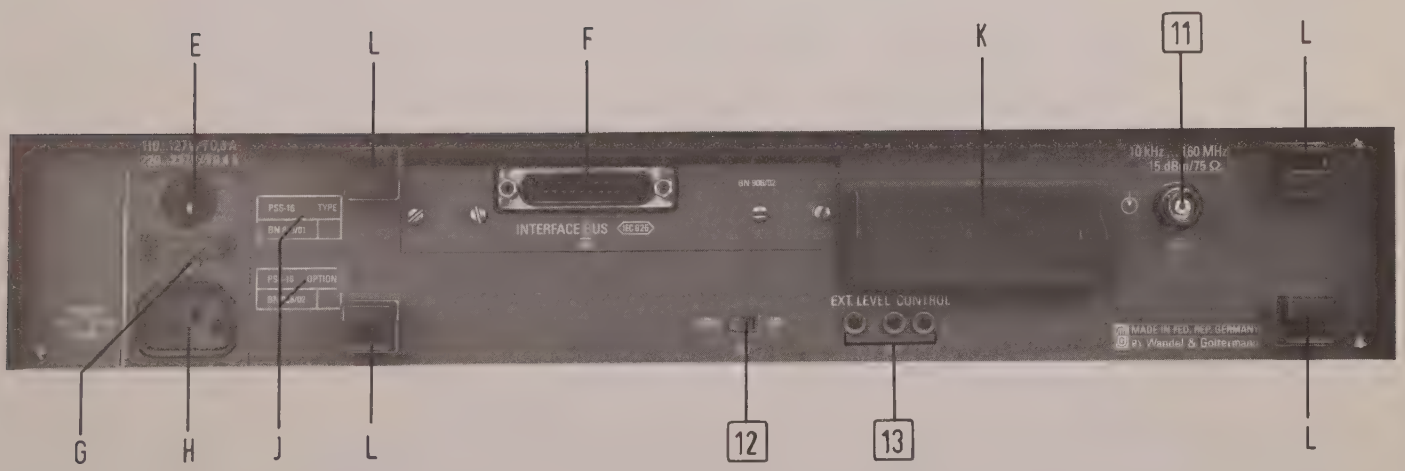


Figure 3-2 Rear view of the PSS-16

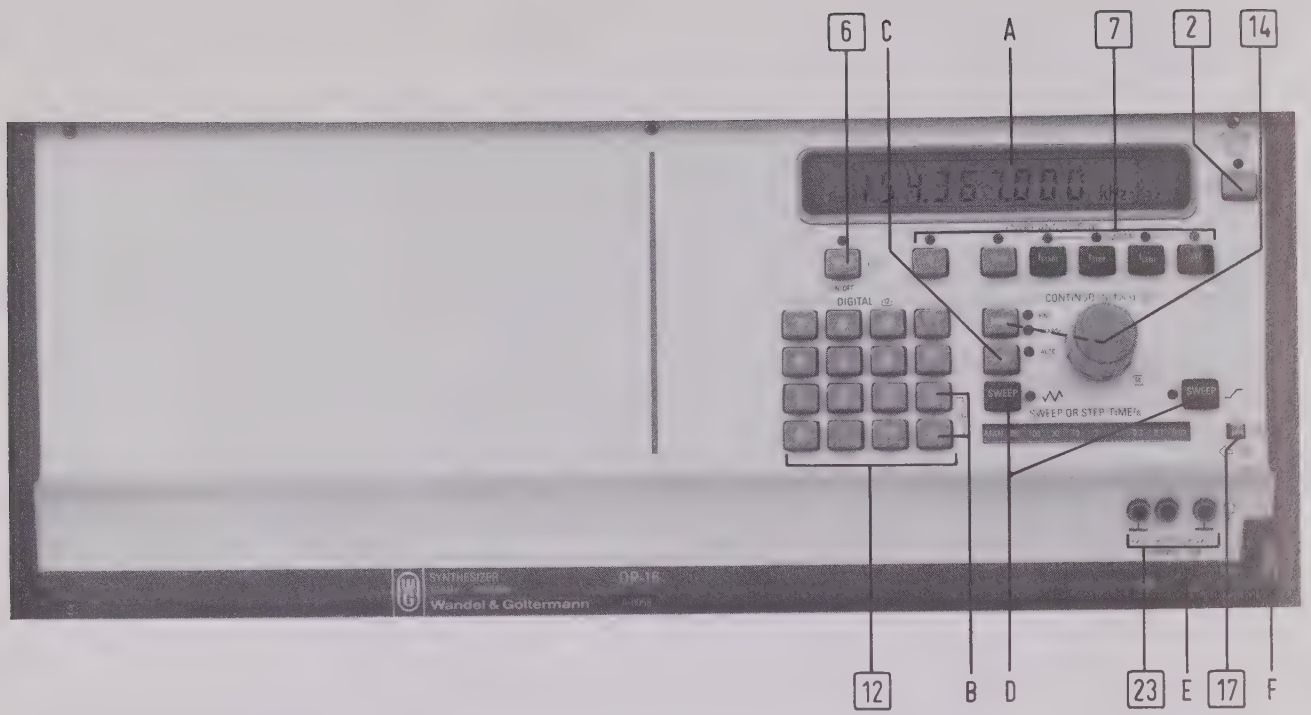


Figure 3-3 Front view of the OP-16

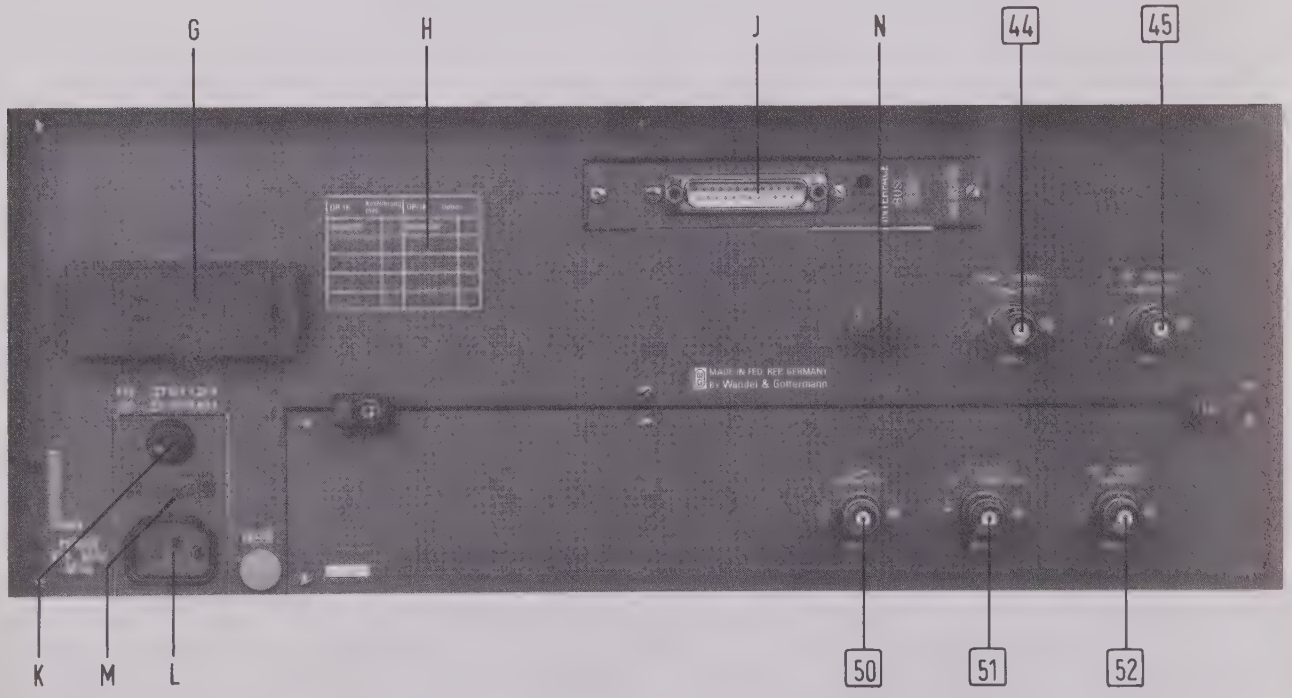


Figure 3-4 Rear view of the OP-16

Code No. of control	Abbreviation in circuit diagrams	Function	
[2]	20 S 42	LOCAL	Key for switching to local mode during remote control
[6]	20 S 12	MEM	Memory key; used together with the keys "STO" and "RCL" for storing and recalling fixed frequencies or setups (frequency parameters)
[7]	20 S 19 ... S 24		Keyboard for entry and display of single frequency f, frequency step f_{STEP}, and sweep limits (f_{START}, f_{STOP} or f_{CENT}, Δf)
[12]	20 S 31 ... S 46		Numerical key pad for measuring parameter entry, multifunction keys for frequency and storage of frequencies and setups
	20 S 43	CLR	Clear key
[14]	18 Mo 1		Knob for continuous frequency tuning together with key "MAN"
[17]	20 S 17		Selection of deflection time in sweep mode (half cycle), dwell time in autostep mode, or manual sweep
[23]	18 Bu 1		X voltage output (DC), voltage proportional to frequency within Δf
A	19 JC 2		Digital display of frequency During selftest or memory operation, this also displays the address, or the test and error number
B	20 S 47 20 S 44	⇧ ⇩	Direction keys for manual frequency stepping with increment f_{STEP}
C	20 S 29	STEP	Key for automatic frequency stepping with increment f_{STEP}
D	20 S 26/S 28	SWEEP	Keys for periodic and single sweep
E	1 Bu 2		Ground socket
F	1 S 1		Mains switch

Table 3-3 Controls and connectors on the front of the OP-16 (see figure 3-3)

Code No. of control	Abbreviation in circuit diagrams	Function
[44]	10 Bu 2	Fixed level output 10 kHz to 160 MHz for control of the Generator Section PSS-16
[45]	10 Bu 1	Control frequency input 220 to 380 MHz, to be connected to [52]
[50]	63 Bu 1	Standard frequency output 10 MHz
[51]	65 Bu 1	Input for external standard frequency 1, 2, 5 or 10 MHz
[52]	58 Bu 1	Control frequency output 220 to 380 MHz, to be connected to [45]
G		Accessory box for spare fuses, assembly wrench, hexagon wrench, and card extractor
H		Equipment data
J	21 (91b)	Insertion position for Interface Bus <IEC 625> board
K	1 Si 1	Mains fuse
L	1 St 1	Mains plug
M		Mains voltage selector
N		Dummy socket

Table 3-4 Controls and connectors on the rear of the OP-16 (see figure 3-4)

3.1.2 CONTROLS

Setting up of the parameters necessary for measurement is carried out primarily with keys. Each key, with the exception of the numerical key pad, has a light-emitting diode (LED) which lights when the function is active.

The rear of the PS-16 carries connector sockets for analog control signals, the insertion position for the remote control board, miscellaneous accessories such as replacement fuses, and elements of the power supply unit. The abbreviations used in the operating instructions for the controls and sockets are shown in the fold-outs Figures 3-1 to 3-4.

The relationship between the abbreviations (normally numbers within square brackets) and the circuit diagrams in the appendix is shown in Tables 3-1 to 3-4.

In the abbreviations of the circuit diagrams, 3 Bu 1 (PSS-16), for example means: the coaxial output socket (1) can be found in circuit diagram 3 and is called Bu 1 in this diagram.

The numbers between square brackets in the tables and text are the same as the numbers shown within boxes on the front and rear of the unit. Keys are referred to in the form "XYZ".

Example: "CLR" refers to the key [CLR]

The table also provides a short overview of the functions of the keys and sockets. All coaxial connection sockets are universal sockets which are easily converted to the most common connectors used in telecommunications (see Chapter 5).

3.2 CONNECTING AND SWITCHING ON

Before switching on the Level Generator or Generator Section, establish the connections shown in Figure 3-5a and 3-5b. All cables are included with the equipment.

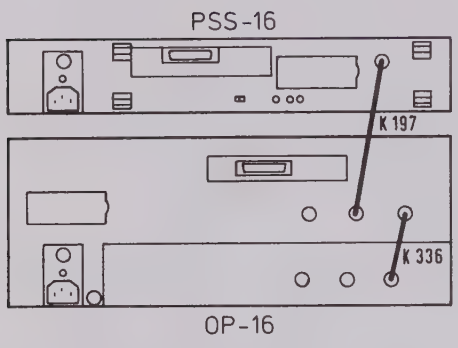


Figure 3-5a Level Generator PS-16 (rear)

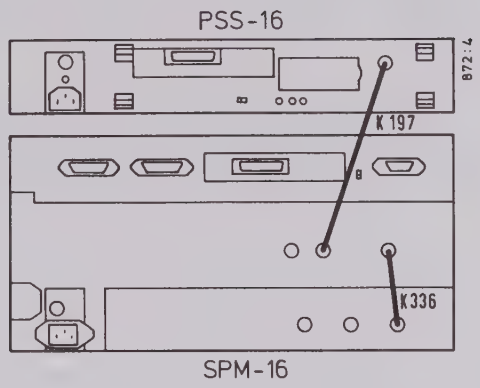


Figure 3-5b Level Measuring Setup PSM-16 (rear)

3.2.1 MAINS CONNECTION

The power supplies of the Generator Section PSS-16 and Synthesizer OP-16 are provided by a switchable power supply unit. With the aid of the voltage selector on the rear of the instrument, the rated values 110/117/127/220/227/237 V can be selected. When the instrument leaves the factory, it is set to a mains voltage of 220 V.

For mains voltages of 110/117/127 V, the fuse link used as the equipment fuse E (PSS-16) or K (OP-16) must be replaced. The following fuse ratings must be used:

Unit	110 ... 127 V	220 ... 237 V
PSS-16	T 0.8 A	T 0.4 A
OP-16	T 1.25 A	T 0.63 A

All fuses have a slow-blow characteristic.

See Chapter 5 for replacement of fuses.

After selecting the correct mains voltage, connect the instrument with the enclosed mains cable to the AC mains supply (47.5 to 63 Hz).

The mains connector is also on the rear of the instrument.

The instruments comply with protection class I in accordance with VDE 0411 or IEC Publ. 348; the chassis and the ground socket are connected to the protective conductor.

The instruments are switched on by depressing the mains switch on the front (push button depressed). The specified error limits are valid after a warming up period of 15 minutes.

3.2.2 INTRINSIC TEST OF OP-16

When the Synthesizer OP-16 is switched on, an RAM/ROM test is automatically executed to check for the correct operation of the random access memory RAM and the operating software (ROM). If the test is successful, the code 0----- appears momentarily in the frequency display before the instrument returns to the last setup which was stored.

In the case of an error in the control section, an error number is shown in the frequency display. An ROM error is indicated by 0--200; see the notes in Chapter 5 in the case of RAM errors.

ROM error

RAM error (see Chapter 5)

Figure 3-6 Display of RAM/ROM errors in the OP-16

3.3 STANDARD SETUP OF OP-16

All equipment setups (frequency parameters) are stored in a semiconductor memory which is supplied with voltage by an accumulator when the OP-16 is switched off. For this reason, the last setup which was entered always appears when the OP-16 is switched on. Stored fixed frequencies are also retained when the power is switched off.

However, the internal rechargeable battery may be discharged if the OP-16 is switched off for a long period, which means that the stored information is lost. In this case, the OP-16 automatically selects the following standard setup when it is switched on again:

f = 100.000 kHz
f_{STEP} = 1.000 kHz
Display "SWEEP OR STEP TIME" = 1 s

The standard setup also appears if the following keys are depressed in the specified sequence:

"MEM, 9001, RCL"

This does not affect stored fixed frequencies and instrument setups.

During repairs, it may be necessary to disconnect the battery, which means that the stored data are again lost. In order to achieve a defined starting status, the key "T" (see Figure 5-2) should be depressed after switching on the OP-16 again. This key is accessible after removal of the upper cover, and causes the standard setup to be loaded into the memory (see also the note below).

If errors occur during operation, switch the OP-16 off and on again in order to execute the RAM/ROM test as described above.

If the test does not result in an error display, although there was an error, it is recommended to execute a RESET by calling program Number 9000 before returning to measurements. This program is called by depressing the following keys:

"MEM, 9000, RCL"

Note: Stored fixed frequencies (address area 0 to 99) are erased, stored front panel setups (address area 100 to 109) are replaced by a standard setup.

3.4 SETTINGS ON THE GENERATOR SECTION PSS-16

The output frequency of the Generator Section is determined by the Synthesizer OP-16 (see Section 3.5) or the Level Meter SPM-16. After the instruments have been switched on, the green LED alongside "LEVEL" on the PSS-16 must light. If this is not the case, check the cable connections specified in Section 3.2 and the power supply as described in Section 3.2.1. After this, connect the 75 Ω output [1] of the PSS-16 to the instrument to be tested via a suitable cable.

3.4.1 SELECTION OF THE LEVEL QUANTITIES

Both absolute and referred levels can be set up on the Level Generator.

After entry of the numerical value for the level via the numeric keypad, the quantities to be used for output and display are determined by depressing one of the following keys:

"dBm" (dB)	absolute level
"dBm0" (dBm)	referred level
"dBr"	relative level (TLP).

These quantities have the following relationship:

(a) dBm0 + (b) dBr = (a + b) dBm.

It is also possible to switch directly between absolute and referred levels by depressing the key "dBm" or "dBm0".

3.4.2 SETTING UP THE OUTPUT LEVEL

The output level is set up either via the numeric keypad or via the direction keys.

3.4.2.1 Level Input via the Numeric Keypad

The numerical value is entered on the numeric keypad [2], the sign ("-" key) being entered before or after the digits in the case of negative levels.

The digits are moved into the level display B from right to left. If an incorrect digit is entered, the display can be cleared with the aid of the clear key "CLR" and the required level re-entered. Any previously entered output level is not affected by this.

The entered level value is transferred to the memory and the complete display updated only after depression of one of the keys "dBm, dBm0, dBr". In the case of entry of relative levels, the numerical value in the "dBr" display A changes; if an absolute level is entered this display is cleared.

Entry of a new level causes the old level to be overwritten.

3.4.2.2 Level Entry via Direction Keys

The absolute or referred level shown in the level display B can be incremented or decremented, depending on the key used, by

10 dB with key [5]
1 dB with key [6]
0.1 dB with key [7].

If the key is held down, the level is changed automatically with appropriate carries into the next decade. The relative level (TLP) cannot be modified with the direction keys.

3.4.3 REACTION TO VALUES OUTSIDE THE LEVEL RANGES

In the case of power level calibration (0 dBm ≙ 1 mW into 75 Ω), the level range is -69.9 to +10 dBm; for voltage level calibration (0 dB ≙ 0.7746 V), it is -69.9 to +1 dB. If levels below this range are entered, the value is limited to the bottom end of the range; if higher values are entered, the following error display appears:

In addition, the LED indicator for level control is switched off.

This can be corrected by re-entering the level via the numeric keypad or holding down the last direction key which was used, in the opposite direction to the warning arrow, until the arrow disappears.

Input of reduced and relative levels is limited to a numerical value ± 69.9. Depending on the value of the relative level, input of the reduced level may result in a warning arrow in either direction in the level display B. This can be corrected as described above.

3.4.4 OUTPUT LEVEL BLANKING

For some measuring tasks, it is necessary to temporarily switch off the output signal from the generator. The key "BLANK" is provided for this purpose. Blanking of the output level is carried out "gradually", i.e. the level does not change instantaneously. This measure avoids interference which could result from the rapid transition during measurements in carrier frequency systems.

When the signal is blanked, the LED display for the level control is off. In addition, the following display appears in the level display B:

When the key is released, the output level is again switched on with a gradual transition.

3.4.5 SWITCHING BETWEEN POWER LEVEL AND VOLTAGE LEVEL

With the aid of the changeover switch [12] on the rear of the instrument the required calibration - either power level (dBm) or voltage level (dB) - can be selected. The Generator Section can remain switched on when this is done. Remote control of this function is not provided.

3.4.6 EXTERNAL LEVEL CONTROL

The output level can be adjusted by approximately ± 1 dB through connection of a DC voltage in the range -1.8 to +1 V to the socket [13] on the rear of the PSS-16.

With the aid of the Milliwatt Power Meter EPM-1 as an AGC amplifier, an external control loop can be constructed. The signal level is extracted as close as possible to the instrument being tested with the Test Probe of the EPM-1. A DC voltage proportional to the deviation from the nominal value is connected from the control voltage output of the EPM-1 to the input socket [13] of the Generator Section. This control loop is particularly useful for eliminating cable losses in the case of longer connecting leads and errors in the generator output impedance or of the test cable. See Chapter 4 for further details.

3.5 TUNING THE SYNTHESIZER OP-16

Tuning is carried out either digitally by the keypad, continuously, or automatically (AUTO STEP), depending on the task.

The use of a synthesizer which is characterized by a low spurious signals and high signal-to-noise ratio and by phase continuity when changing frequencies ensures that the accuracy and stability of the selected frequency are extremely high in all operating modes. The frequency inaccuracy of the OP-16 is $\pm$ 1 x 10^{-7} of the displayed frequency value. This error specification includes the temperature drift within the rated range of use and the aging error within one year.

3.5.1 DIGITAL TUNING [12]

The required receive frequency is entered in MHz or kHz with the aid of the keypad [12] (the LED above the blue key "MEM" must be off).

Example: f = 4.950 MHz "4.95" "MHz"

Leading or trailing zeros (1 Hz to 100 Hz position) may be omitted. The Synthesizer is tuned to the new value only after depression of the key "MHz" or "kHz" (ENTER function).

If a digit is entered incorrectly during frequency input, the display can be cleared with the clear key "CLR" and the required frequency re-entered. Tuning of the synthesizer is not affected by this. The digits are moved into the display from right to left.

Entry of a new frequency is carried out by overwriting the old value.

The tuned frequency is displayed in display window A with a maximum of 9 digits and a resolution of 1 Hz. The display is always in kHz.

3.5.2 CONTINUOUS FREQUENCY TUNING "MAN"

Depression of the key "MAN" on the function panel [13] selects continuous frequency tuning.

Tuning is carried out in a pseudo-continuous mode, i.e. in steps of 1 Hz or 100 Hz:

with a resolution of 1 Hz (FINE) if the the key "MAN" is depressed once;

with a resolution of 100 Hz (COARSE) if the key "MAN" is depressed twice.

Due to the phase-continuity of the synthesizer, no sudden phase shifts occur during manual tuning, which means that no additional sideband spectrum is generated.

After previous selection of the coarse or fine tuning mode, the frequency can be tuned over the whole range with the knob [14], without further switching, the rate of frequency change per revolution of the knob also increasing if the knob is turned faster. This permits rapid tuning over the whole frequency range.

If 100 Hz resolution is selected for tuning, the last two digits of the frequency display remain zero.

To switch back to digital tuning, simply enter the required frequency via the keypad [12].

3.5.3 TUNING IN STEPS

In the case of measurements at constant frequency intervals (e.g. at channel or primary group spacing or for recording frequency plan sequences),operation is particularly simple if the frequency can be set with the aid of a stored frequency increment. The OP-16 permits both manual and automatic frequency stepping.

3.5.3.1 Single Step Tuning

- Depress "f_{STEP}".
- Enter the required frequency step in MHz or kHz (see 3.5.1).
- Depress "f" and enter the starting frequency (see 3.5.1).
- Adjust the frequency step-by-step upwards or downwards with the two direction keys ⇧ ⇩ STEP
  Tuning is possible over the whole frequency range.
  The frequency step can be checked by again depressing the key "f_{STEP}". The value is changed by overwriting with a new value.

3.5.3.2 Automatic Frequency Stepping

This type of tuning is worthwhile only if the start and stop frequencies are also entered.

Example: Carry out measurements from 1 MHz to 12 MHz with a step of 1 MHz.

Depress the following keys:

- "f_{START}" 1 "MHz" "f_{STOP}" 12 "MHz"
- "f_{STEP}" 1 "MHz"
- Depress key "AUTO STEP".

The frequency now automatically steps at the rate selected on the "STEP TIME" switch [17]. Frequency stepping starts at the last limit frequency entered (in the example above f_{STOP}) and is repeated cyclically, starting each time at f_{START}.

The stepping can be stopped by depressing the key "f" or any other key in the function field [7] or [13].

Note: If the frequency sweep $\Delta f = f_{STOP} - f_{START}$ is not an integral multiple of f_{STEP}, then measurements are carried out only as far an upper frequency $f'_{STOP} = n \cdot f_{STEP} \leq f_{STOP}$, i.e. the selected limits are never exceeded. Tuning outside the limits is possible only with the two STEP direction keys "B". If the key "AUTO STEP" is subsequently depressed, the frequency returns to a value within the limits.

3.5.4 TRANSFER OF THE FREQUENCY SETTING INTO THE MEMORIES FOR f_{STEP} AND SWEEP LIMITS

If the key "f" is held down and one of the keys under ENTRY AND DISPLAY [7] is depressed, then the previously entered frequency can be transferred directly to the memories for f_{STEP} and for sweep limits.

3.6 S W E E P O P E R A T I O N

The sweep frequency method is used for continuous recording of a measured value curve, a distinction being made between loop and end-to-end measurements. Because, in the case of a loop measurement, the level generator and level meter are at the same location, and since the transmit and receive frequencies are generally identical, synchronous tuning by a common oscillator, for example in the level meter, is sufficient for selective sweep operation. The Generator Section PSS-16 is suitable as a signal source for this measuring task. The configuration of such a measuring set consisting of the PSS-16, SPM-16, and Display Unit, and the settings of the sweep limits, are described in the Description and Operation Instructions for the SPM-16, Section 4.13.

The combination of PSS-16/OP-16 together with a wideband level meter results in a sweep frequency measuring set suitable for end-to-end measurements for setting up or of for routine checks on carrier frequency transmission paths. Details of the measuring principle are described in Chapter 4 and in the Application Note No. 13 (Order No. 50516).

Frequency sweeping is carried out digitally with an increment which depends on the sweep range and the sweep rate. These are calculated by the microcomputer, taking into account the step time of 60 µs.

3.6.1 SETTING UP THE SWEEP LIMITS

This depends on the application.
In the case of wideband systems to be tested, it is advantageous to enter
f_{START} = lower (upper) sweep limit and
f_{STOP} = upper (lower) sweep limit
via the keypad [12] (see 3.5 1).

In the case of narrow band test objects,
f_{CENT} = centre frequency and
Δf = sweep width ($f_{STOP} - f_{START}$)
are entered (see 3.5.1).

Example: f_{CENT} = 10 MHz, Δf = 10 kHz
Input: "f_{CENT}" 10 "MHz" "Δf" 10 "kHz"

The sweep limits (in the example above 9.995 and 10.005 MHz) can be read off from the frequency display after depressing the keys "f_{START}" and "f_{STOP}".

Note: A frequency appearing in the display and allocated to the key "f" can be transferred to the memory for the parameters in the input panels [7] if the "f" key is held down and one of the keys in panel [7] is depressed.

3.6.2 SWEEP MODE AND DEFLECTION TIME

With the aid of the two sweep keys, it is possible to select either
"SWEEP" ⩘ periodic, triangular sweep

"SWEEP" ⟋ single sweep
If the key whose function is active is momentarily depressed during sweep operation, the direction of the sweep is reversed.

The sweep rate
corresponds to one sweep and is set in the range 0.03 to 300 s with the changeover switch [18].

For a single sweep, the starting frequency is selected by depressing the key "f_{START}" or "f_{STOP}", and the sweep operation can then be started by depressing the "SWEEP" ⟋.

Linearity checking (transient response of the test object) can be checked either visually (the forward and reverse traces on the screen must coincide) or by holding down the sweep key "SWEEP" ⩘. In the latter case, the sweep is stopped momentarily at regular intervals. If the test object has not settled correctly, the result is a staircase wave form of the swept curve, and the sweep rate should be decreased. Depression of the sweep key for this check is particularly useful with slow sweep rates and a display unit with a short persistence of the CRT.

If the "SWEEP" key is depressed during sweep operation, the sweep direction is reversed.

3.6.3 MANUAL DEFLECTION

In the position "MAN" of the toggle switch [17], and after depression of one of the keys "SWEEP", the frequency can be swept manually with the knob [14] within the sweep limits set up as described in Section 3.6.1. The X deflection voltage at output [23] is proportional to the sweep deflection and lies within the range $\pm$ 2.5 V.

If the knob [14] is turned slowly, the frequency varies proportionally; if it is turned rapidly, the frequency changes at an increased rate. The sweep limits are maintained in all cases.

3.6.4 DC (X) OUTPUT [23]

The DC (X) output [23] delivers a deflection voltage which is proportional to the frequency within the frequency limits f_{START} and f_{STOP}, for example for driving a plotter or display unit.

Regardless of the selected range, the open circuit voltages are
-2.5 V at f_{START}
+2.5 V at f_{STOP}
with an internal resistance of 5 kΩ.

3.7 MEMORY FUNCTIONS IN THE OP-16

With the aid of the blue key "MEM" under ENTRY SELECT, up to 100 fixed frequencies and 10 equipment setups (frequency parameters) can be stored and recalled when required. This permits rapid execution of those measurements which are carried out frequently at the same frequencies and under the same measuring conditions. When the OP-16 is switched off, or if the mains supply fails, a built-in Ni-Cd battery provides voltage for the memories such that stored data are retained for approximately four weeks. If it is necessary to store the parameters and data for a longer period, the Auxiliary Device "PROM" BN 872/00.01 can be fitted (see Section 3.9.1), this being programmed in accordance with the customer's specifications.

3.7.1 ADDRESS ORGANIZATION

Table 3-5 provides an overview of the addressable memory positions (address and program numbers) and their contents. As this shows, 100 fixed frequencies and 10 complete equipment setups (frequency parameters) can be programmed as required. The parameters and data are stored in a RAM and are not lost if the OP-16 is switched off (see 3.7). They can be overwritten by new entries.

In addition, in accordance with the customer's specifications, an optional EPROM permits storage of a further 100 fixed frequencies and 40 equipment setups (frequency parameters) (see 3.9.1).

Table 3-6 shows the special programs which can be recalled.

If an attempt is made to store or recall frequencies, special programs, or instrument setups with invalid addresses or program numbers, an error number (e.g. 2--001 ≙ invalid address number) appears in the frequency display of the OP-16. Table 5-1 shows the meanings of the error numbers.

Addresses	Contents
0 ... 99	Fixed frequencies in RAM
100 ... 109	Setup in RAM
200 ... 299	Fixed frequencies in ROM
300 ... 339	Setup in ROM

Table 3-5 Organization of the measuring parameter memory

Program Number	Contents
9000	Initial program load *)
9001	Standard setup as shown in Section 3.3
9002	RAM and ROM test (switch off by depressing the key "MEM")

Table 3-6 Recalling special programs by a memory address (see Section 3.7.2)

*) Note: The program number 9000 should be recalled only when really required, for example for clearing the complete fixed frequency RAM, as the contents of all addresses 0 to 99 are cleared and the contents of all addresses 100 to 109 are overwritten with the "standard setup" as described in Section 3.3 (initial program load). If the RAM power supply from the built-in NiCd battery was interrupted, for example during a repair, it is recommended to call address 9000 or to depress the key "T" below the top cover of the OP-16 (see also Section 3.3 and Figure 5-2).

3.7.2 THE STORE AND RECALL FUNCTIONS

With the aid of the two keys "STO" and "RCL" on the control panel [12] of the OP-16, data and measuring parameters can be stored and recalled when required. After entry of the parameters, the following keys should be depressed:

To store: "MEM" Address number "STO"
The LED above the "MEM" key flashes until the function key "STO" is depressed. An error number appears if an invalid address is selected.

To recall: "MEM" Address number "RCL"
The LED above the "MEM" key flashes until the function key "RCL" is depressed. An error number appears if an invalid address number is selected (see 3.7.1). After the recall has been executed, the MEM function remains active. Further addresses can be recalled directly via the numeric keypad or sequentially by depressing the two direction keys ⇧ and ⇩. Automatic stepping is possible for the addresses 0 to 99 and 200 to 299 (see 3.7.5b).
When the MEM function is active, the selected address number remains visible in the frequency display as long as the "RCL" key is depressed.

3.7.3 STORING FIXED FREQUENCIES

Capacity: Up to 100 fixed frequencies
Address range: 0...99 (see Table 3-5)

- Enter required frequency via the keypad (see 3.5.1)
- Depress "MEM" (LED must light)
- Select required memory position (address) via keypad [12]
- Depress "STO"
- Enter the next frequency.

If it is necessary to store a large number of fixed frequencies sequentially, the necessity of noting the last address which was stored can be avoided by a different entry procedure, as follows:

Enter first frequency
"MEM" on - enter first address - "STO" -
"MEM" on - step ⇧ - "MEM" off

Enter second frequency
"MEM" on - "STO" - "MEM" on - Step ⇧ etc.

3.7.4 RECALLING RANDOM FIXED FREQUENCIES

From the address areas 0 ... 99 and 200 ... 299 (only with the Auxiliary Device "PROM" BN 872/00.01).

- Depress "MEM"
- Enter required address via keypad [12]
- Depress "RCL". The required frequency now appears in the frequency display.

As the MEM function remains active, further fixed frequencies can then be recalled by simply entering the address.

3.7.5 RECALLING A SEQUENCE OF FIXED FREQUENCIES

If measurements are to be carried out at several frequencies which are stored at sequential addresses in the RAM, setting up can be simplified considerably by manual or automatic recall.

a) Manual recall
   - Select the required starting address as described in 3.7.4
   - The following fixed frequencies are recalled with the two keys ⇧ ⇩. The MEM function remains active. The corresponding address number is displayed if the key "RCL" is depressed.

b) Automatic recall

In this operating mode, the start and stop addresses (frequencies) are specified. Measurements are then always carried out within the selected limits.

- Set up the required step time in the display window "SWEEP OR STEP TIME/S" with the toggle switch [17].
- Depress "MEM".
- Depress "f_{START}" and enter the start address via the numeric keypad.
- Depress "RCL". The frequency of the start address is now transmitted.
- Depress "f_{STOP}" and enter the stop address via the numeric keypad.
- Depress "RCL". The frequency of the stop address is now transmitted.
- Depress "AUTO STEP". The frequency of the stop address is transmitted until the step time has elapsed, and is then followed by the frequency of the start address.

The frequencies are now stepped cyclically between the start and stop addresses. After one sweep, the OP-16 starts again at the start address. Depending on the setup, frequency stepping is carried out either from a low to a high or from a high to a low address number. If the OP-16 is switched off and on again, it automatically sets up the last operating status.

Switching off automatic address stepping

- Depress "f" (switches off the AUTO STEP function).
- Depress "MEM" (switches off the memory function).

Notes:

- Checking the processing status:
  Depress "RCL". As long as this key is held down, the current address being processed is shown in the frequency display.
- Dynamic address modification during an AUTO STEP run:
  Enter the required address and depress "RCL".
- Interrupting the AUTO STEP sequence and resuming later at the interruption point:
  Depress "f" (switches off the AUTO STEP function).
  Depress "AUTO STEP" (restarts the function).

3.7.6 STORING EQUIPMENT SETUPS (FREQUENCY PARAMETERS)

Capacity: Up to 10 complete front panel setups
Address area: 100 ... 109 (see Table 3-6)

With the exception of the AUTO STEP function, all functions and parameters which can be set up on the front panel can be stored. Storing and recalling is carried out as described in Section 3.7.2:

- Enter the required frequency parameters and data
- Depress "MEM" (LED must light)
- Enter the required memory position (address) via keypad [12]
- Depress "STO"
- Enter the next equipment setup.

3.7.7 RECALLING EQUIPMENT SETUPS
(FREQUENCY PARAMETERS)

From the address areas 100 ... 109 and 300 ... 339 (only with Auxiliary Device "PROM" BN 872/00.01) is carried out as described in Section 3.7.2:

- Depress "MEM"
- Select the required address (setup) via keypad [12]
- Depress "RCL".

As the MEM function remains active, further setups can then be called by entering the address or by depressing the direction keys [⇧] and [⇩] (see 3.7.5a).

3.8 S T A N D A R D F R E Q U E N C Y I N P U T [51]

If, for specific measuring tasks, the frequency accuracy of the OP-16 is not sufficient, the error in the tuned frequency can be reduced by connecting a more precise, external standard frequency of 1, 2, 5 or 10 MHz to socket [51] on the rear of the instrument. The input level for a sinusoidal signal may lie between -10 and +10 dBm; in the case of a squarewave signal, the peak-to-peak voltage V_{pp} may lie between 200 mV and 2 V (input impedance 75 Ω).

3.9 A U X I L I A R Y D E V I C E S

3.9.1 PROM BN 872/00.01 FOR OP-16

This memory module permits storage of up to 100 additional fixed frequencies and 40 additional complete front panel setups (frequency parameters). The required frequency values and setups should be specified when ordering the Auxiliary Device BN 872/00.01 in order to avoid delivery delays (see Section 3.9.1.1).

3.9.1.1 Fixed Frequencies and Equipment Setups

The fixed frequencies and equipment setups specified by the customer are stored, as shown in Table 3-5, in:

Address area 200 ... 299 for fixed frequencies
Address area 300 ... 339 for equipment setups

and are recalled as described in Sections 3.7.2 to 3.7.7. If the PROM BN 872/00.01 is not fitted in the OP-16, an error number (2--006 ≙ address not programmed) appears in the frequency display A if one of the above addresses is selected.
See Chapter 5 for the meanings of the error numbers.

When ordering the Option, Form Number 5/797a for equipment setups (Part I) and/or Form Number 5/797b for fixed frequencies (Part II) must be filled out completely. Figures 3-7 and 3-8 show samples of these ordering forms. Column 1 of each form contains an example of the entries.

If more than 10 equipment setups are required, further forms No. 5/979a should be added, numbering the pages sequentially. Please enter all level and frequency values, even if these are only partially required.

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☐ **PS-16**
☐ **OP-16**
Option BN 872/00.01

Bestellvorschrift
Ordering instructions

Nr. ☐☐☐

Blatt / Sheet ...

Teil I / Part I: Geräteeinstellungen / Instrument settings		Kunde / Customer	Bestell-Nr. / Order No.
OP-16, Nr.:	**AB:**		
geprüft: / erstellt (Datum):	**T:**		
		Festfrequenzen / Fixed Frequencies (Teil II / Part II) ja / yes ◯ nein / no ◯	

Gewünschte Frequenzeinstellungen und Zahlenwerte ● eintragen. Mit Adreßnummer 300 beginnen
(Max. bis Adresse 339); bei >10 Setups weitere Vordrucke verwenden.

Enter wanted settings and ● numerical values. Begin with address No. 300.
(Max. to address 339); with >10 setups, use another printed form.

Adresse / Address No.	Beispiel / Example					
Cont: Man Fine [0], Coarse [1]						
Sweep [5] [6] 1)	[9]	☐	☐	☐	☐	☐
Off (dig. setting) [9]						
Rate/s ●	1	.....	.....	.....	.....	.....
oder/or Man 2) [0]	☐	☐	☐	☐	☐	☐
	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz
Frequenz/Frequency f 3) ●	1 2 3 4 5 6					
f_{START} ●	1 2 3 4 5 6					
f_{STOP} 4) ●	6 7 8 9 0 0 0					
f_{STEP} ●	1 0 0 0					

(Fortsetzung/continued)

Adresse / Address No.	Beispiel / Example					
Cont: Man Fine [0], Coarse [1]						
Sweep [5] [6] 1)	[5]	☐	☐	☐	☐	☐
Off (dig. setting) [9]						
Rate/s ●	—	.....	.....	.....	.....	.....
oder/or Man 2) [0]	[0]	☐	☐	☐	☐	☐
	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz
Frequenz/Frequency f 3) ●	1 2 3 4 5 6					
f_{START} ●	1 2 3 4 5 6					
f_{STOP} 4) ●	6 7 8 9 0 0 0					
f_{STEP} ●	1 0 0 0					

1) Die Funktion AUTO STEP ist nur manuell aufrufbar
2) Zusätzlich bei Sweep 5 eintragen
3) Bei Frequenzabläufen Anfangsfrequenz eintragen
4) Hier stets einen Zahlenwert eintragen, auch wenn Setup ohne Wobbel- oder f_{STEP}-Funktion

1) The function AUTO STEP is only callable manually
2) Enter additionally with Sweep 5
3) Enter beginning frequency with frequency run
4) Here, always enter a numerical value, even when Setup without sweep or f_{STEP}-function

5/797a

Figure 3-7 Ordering Form No. 5/797a

Aussteller bitte nur die stark umrandeten Felder vollständig ausfüllen

Orderer: Please fil out completely within thickly drawn frames

☐ **PS-16**
☐ **OP-16**
Option BN 872/00.01

Bestellvorschrift
Ordering Instructions

Nr.

Teil II / Part II: Festfrequenzen / Fixed Frequencies

OP-16, Nr.:	AB:
geprüft: / erstellt (Datum):	T:

Kunde / Customer	Bestell-Nr. / Order No.

Geräteeinstellungen / Set-ups (Teil I / Part I) ja / yes ◯ nein / no ◯

Gewünschte Festfrequenzen in **Hz** eintragen. Adressbereich 200–299 / Enter wanted fixed frequencies in **Hz**. Address area 200–299

MEM z. B. / e. g.	MHz 1 2	kHz 3 4 5	Hz 6 7 8	MEM	MHz	kHz	Hz	MEM	MHz	kHz	Hz
200				235				270			
201				236				271			
202				237				272			
203				238				273			
204				239				274			
205				240				275			
206				241				276			
207				242				277			
208				243				278			
209				244				279			
210				245				280			
211				246				281			
212				247				282			
213				248				283			
214				249				284			
215				250				285			
216				251				286			
217				252				287			
218				253				288			
219				254				289			
220				255				290			
221				256				291			
222				257				292			
223				258				293			
224				259				294			
225				260				295			
226				261				296			
227				262				297			
228				163				298			
229				264				299			
230				265							
231				266							
232				267							
233				268							
234				269							

5/797b

Figure 3-8 Ordering Form No. 5/797b

Aussteller bitte nur die stark umrandeten Felder vollständig ausfüllen

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☐ **PS-16**
☐ **OP-16**
Option BN 872/00.01

Bestellvorschrift
Ordering Instructions

Nr.

Blatt
Sheet

Teil I / Part I: Geräteeinstellungen / Instrument settings		Kunde / Customer	Bestell-Nr. / Order No.
OP-16, Nr.:	**AB:**		
geprüft: / erstellt (Datum):	**T:**	Festfrequenzen / Fixed Frequencies (Teil II / Part II) ja / yes ◯ nein / no ◯	

Gewünschte Frequenzeinstellungen und Zahlenwerte ● eintragen. Mit Adreßnummer 300 beginnen
(Max. bis Adresse 339); bei >10 Setups weitere Vordrucke verwenden.

Enter wanted settings and ● numerical values. Begin with address No. 300.
(Max. to address 339); with >10 setups, use another printed form.

Adresse / Address No.	Beispiel / Example					
Cont: Man Fine [0], Coarse [1] Sweep [5] [6] 1) Off (dig. setting) [9]	[9]	☐	☐	☐	☐	☐
Rate/s ●	1	.....	.....	.....	.....	.....
oder/or Man 2) [0]	☐	☐	☐	☐	☐	☐
	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz
Frequenz/Frequency f 3) ●	1 2 3 4 5 6					
f_{START} ●	1 2 3 4 5 6					
f_{STOP} 4) ●	6 7 8 9 0 0 0					
f_{STEP} ●	1 0 0 0					

(Fortsetzung/continued)

Adresse / Address No.	Beispiel / Example					
Cont: Man Fine [0], Coarse [1] Sweep [5] [6] 1) Off (dig. setting) [9]	[5]	☐	☐	☐	☐	☐
Rate/s ●	—	.....	.....	.....	.....	.....
oder/or Man 2) [0]	[0]	☐	☐	☐	☐	☐
	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz	MHz kHz Hz
Frequenz/Frequency f 3) ●	1 2 3 4 5 6					
f_{START} ●	1 2 3 4 5 6					
f_{STOP} 4) ●	6 7 8 9 0 0 0					
f_{STEP} ●	1 0 0 0					

1) Die Funktion AUTO STEP ist nur manuell aufrufbar
2) Zusätzlich bei Sweep 5 eintragen
3) Bei Frequenzabläufen Anfangsfrequenz eintragen
4) Hier stets einen Zahlenwert eintragen, auch wenn Setup ohne Wobbel- oder f_{STEP}-Funktion

1) The function AUTO STEP is only callable manually
2) Enter additionally with Sweep 5
3) Enter beginning frequency with frequency run
4) Here, always enter a numerical value, even when Setup without sweep or f_{STEP}-function

5/797.a

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Orderer: Please fill out completely within thickly drawn frames

☐ **PS-16**
☐ **OP-16**
Option BN 872/00.01

Bestellvorschrift
Ordering Instructions

Nr.

Teil II / Part II: Festfrequenzen / Fixed Frequencies

OP-16, Nr.:	**AB:**
geprüft: / erstellt (Datum):	**T:**

Kunde / Customer	Bestell-Nr. / Order No.

Geräteeinstellungen / Set-ups (Teil I / Part I) ja / yes ◯ nein / no ◯

Gewünschte Festfrequenzen in **Hz** eintragen. Adressbereich 200–299 / Enter wanted fixed frequencies in **Hz.** Address area 200–299

MEM z. B. / e. g.	MHz 1	MHz 2	kHz 3	kHz 4	kHz 5	Hz 6	Hz 7	Hz 8
200								
201								
202								
203								
204								
205								
206								
207								
208								
209								
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212								
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222								
223								
224								
225								
226								
227								
228								
229								
230								
231								
232								
233								
234								

MEM	MHz	kHz	Hz
235			
236			
237			
238			
239			
240			
241			
242			
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248			
249			
250			
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255			
256			
257			
258			
259			
260			
261			
262			
163			
264			
265			
266			
267			
268			
269			

MEM	MHz	kHz	Hz
270			
271			
272			
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274			
275			
276			
277			
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5/797 b

3.9.2 REMOTE CONTROL BOARD <IEC 625>

With the aid of the remote control board, the instruments can be controlled by an external controller (computer). They can then be included in automatic measuring systems and handle comprehensive measuring tasks not only precisely and reliably, but with savings in time and costs. Figure 3-9 shows the configuration of a simple automatic level measuring system, which is capable of further expansion.

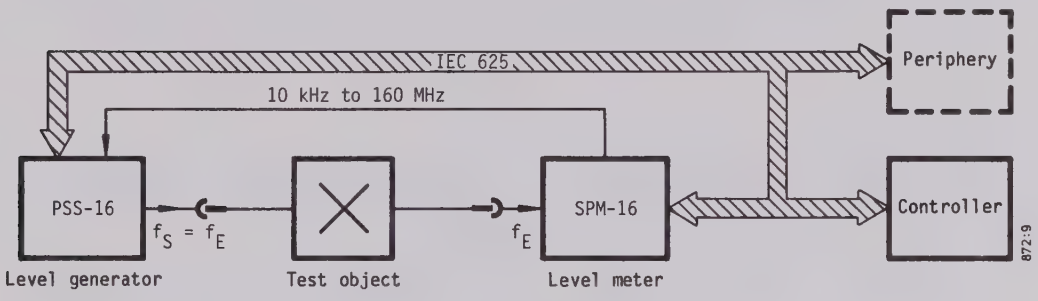


Figure 3-9 Block diagram of a simple automatic level measuring system

Computer control is carried out via an interface board with the internationally standardized interface in accordance with <IEC 625>, which can be fitted on the rear of the OP-16 if required.

Connection to systems with IEEE 488 interfaces is possible via the adaptor plug S 834. Subsequent installation of the interface board is carried out as described in Chapter 5. The external control of the different instruments is indicated by the red LED above the key "LOCAL". Manual operation via keypad input is inhibited as long as this LED is on.

The instruments can be switched to local control in accordance with the conditions described in the IEC Bus Standard (remote-local function RL1), even with the computer connected, by depressing the "LOCAL" key. Details of programming of the equipment can be found in the separate handbook "Remote Control and Programming Instructions BN 870/874".

3.9.2.1 Interface Board <IEC 625> for OP-16, BN 853/02

The principle of operation of this board and the interaction between the OP-16 and IEC Bus Interface are described in detail in the description and operating instructions for the Level Meter SPM-16.

3.9.2.2 Interface Board <IEC 625> for PSS-16, BN 873/00.01[1)]

The Generator Section PSS-16, in contrast to the Synthesizer OP-16, does not have a microprocessor module. Matching to the <IEC 625> Interface is therefore implemented in two plug-in boards:

---

1) Old designation BN 906/02

- By a device-specific bus adaptor board [873-F], which mainly contains entry registers as buffers for the matching of the interface to the Generator Section, and
- by a universal interface board BN 906/01 in Europa format. This IEC Bus Interface has the task of accepting the byte-serial data received from the computer and converting into bit and byte parallel data and, in the reverse direction, converting parallel data from the device into serial data for the IEC Bus. Amongst other things, the board contains an LSI module in which the most common IEC functions are implemented.

  The parallel poll bit (Switch S 1) and the device address (Switch S 2) can be set up with two 8 pole miniature switches (see Figure 5-2).

  Each of the signals "generator off, unacceptable generator level range ↓↓, out of control range, remote control" can be transmitted as a status byte to the controller.

3.9.2.3 Bus Specification and Bus Plug

Up to 15 devices can be interconnected in parallel via the standardized interface in an automatic measuring system compatible with the IEC Bus.

Each device is connected via a cable with a maximum length of 2 m to the bus. The complete bus length of the system may not exceed 20 m. Longer distances can be achieved by inserting interface couplers (via 2 wire or 4 wire connections) or modems.

The ISO-7 bit code or the ASCII code is used for encoding of characters, and transmission is carried out in parallel by bit and serial by byte.

The pin assignments of the bus plug on the device are shown in Figure 3-10. The main difference between the <IEC 625> connector and the IEEE 488 connector lies in the version of the plug (IEC: 25 pin Cannon plug; IEEE: 24 pin Amphenol plug) and in the pin assignments. The test equipment with IEC connection can, however, easily be connected to controllers with IEEE interfaces by use of the adaptor plug S 834, which is delivered with the interface board.

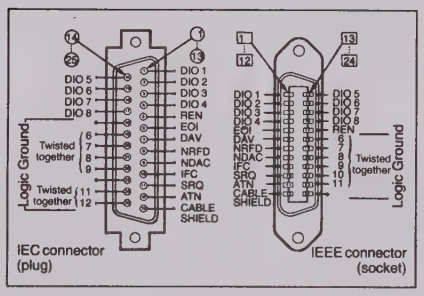


Figure 3-10 Pin assignments on device bus connector

3.10 MEASURING ACCESSORIES

3.10.1 IMPEDANCE MATCHING CIRCUIT FEDA-1 (75 Ω/50 Ω)

With the aid of impedance matching circuit 75 Ω/50 Ω, the output impedance of the generator output or the input impedance of the receiver input can be matched to an impedance of 50 Ω. The available socket adaptors are listed in Section 5.3.6.

If a 75 Ω cable is used as the measuring lead, then the impedance matching circuit must be fitted at the end connected to the test object (see Figure 3-11); if a 50 Ω cable is used, it must be fitted at the test equipment end.

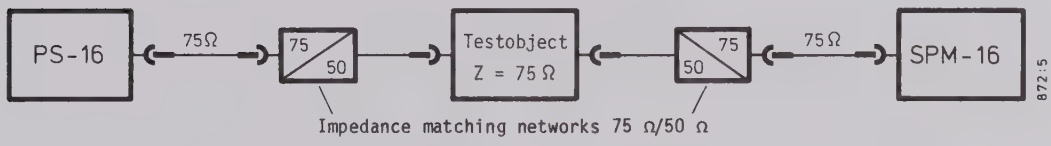


Figure 3-11 Measuring at an impedance of 50 Ω

When setting up the generator level or reading off the received level, the insertion loss of 2 x 6 dB of the impedance matching circuits must be taken into account. This can be done in the PS-16/SPM-16 combination by transferring this value into the memory for reference level (dBr) (see description and operating instructions for SPM-16). The error limits specified in the technical data for the Level Generator and the Level Meter may be increased slightly by the attenuation and frequency response errors and the reflection coefficient of the impedance matching circuit.

4 MEASURING NOTES

4.1 EXTERNAL CONTROL OF THE OUTPUT LEVEL

The output level of the PSS-16 or PS-16 can be kept virtually constant over the whole frequency range with the aid of the Milliwatt Power Meter EPM-1. In this case, the EPM-1 acts as a AGC amplifier and forms a closed control loop with the Generator.

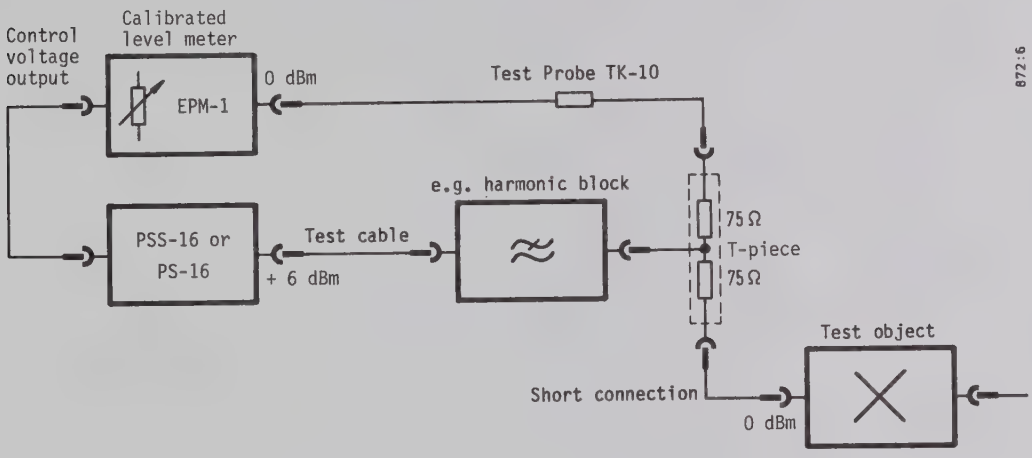


Figure 4-1 Test configuration for external level control

In the example shown in Figure 4-1, the output signal is connected via a low-pass filter, which acts as a harmonic block, to the unit being tested. A T-piece distributes the output level of approximately 6 dB equally to the test object and the Test Probe TK-10 of the Milliwatt Test Set. A DC voltage proportional to the deviation from the set value is connected from the control voltage output of the EPM-1 back to the input "external level control" of the Generator. This control loop results in an extremely precise level at the input to the test object, which is independent of the frequency, as any errors resulting from the pass-band attenuation and ripple of the low-pass filter, from the losses in the test cables, and from reflection at the transfer points are taken into account. The remaining error is determined only by the frequency response of the Test Probe, the control error of the EPM-1, and any imbalance in the T piece.

4.2 APPLICATION EXAMPLES FOR SWEEP MEASUREMENTS

4.2.1 SELECTIVE SWEEP FREQUENCY MEASURING SET

In the case of selective sweep frequency measurements, the transmit and receive frequencies are swept synchronously by the oscillator section of the Receiver. The Generator and the Receiver must therefore be located close to each other (loop-back measurement). The Display Unit is connected via a 14 wire cable K 145. The Amplifier Plug-ins SGV-21 and SGH-21 are required, and the Reference Traces SGR-21 and SGR-22 are useful accessories.

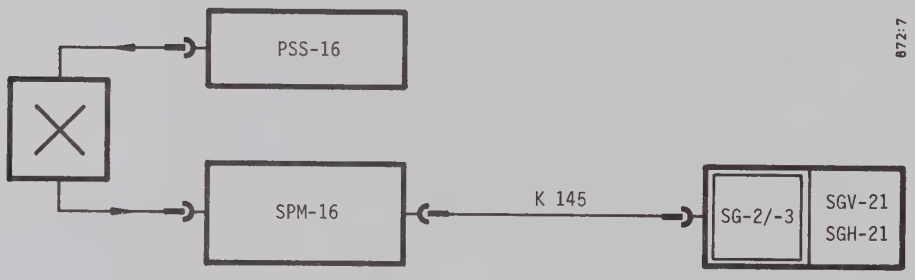


Figure 4-2 Sweep frequency measuring set WM-16 for loop-back measurements

4.2.2 END TO END SWEEP FREQUENCY MEASUREMENTS

In the case of end-to-end measurements, the Level Generator and Level Meter are some distance apart; the only connection between the two instruments is the transmission path to be measured. As auxiliary connections cannot generally be established, the level at the receive location B must be measured with a wide bandwidth. In this case, Display Unit Plug-in "Wideband Level Meter SGP-100" carries out level evaluation.

In order to generate the X deflection voltage from the measured frequency, the Frequency Discriminator SGD-21 is required. The equalization of losses in carrier frequency cable systems is easily and rapidly executed with the aid of the Ripple Meter SGW-21.

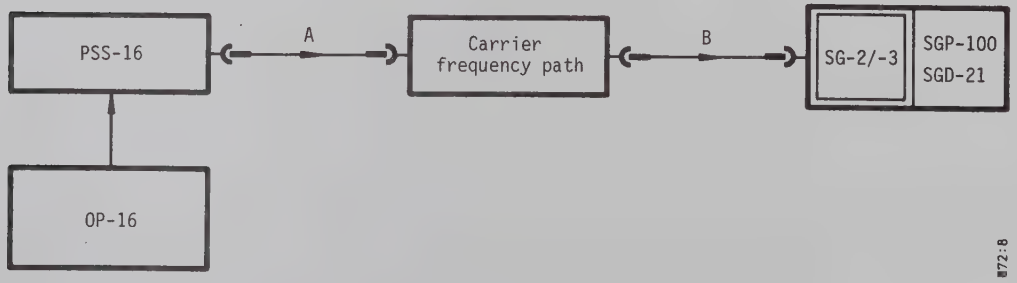


Figure 4-3 Wideband end-to-end sweep frequency measurements

5 FUNCTIONAL TEST, MAINTENANCE, AND MISCELLANEOUS

The following information permits correct operation of the Generator Section PSS-16 or of the Synthesizer to be checked in order to determine whether the equipment has any major faults (e.g. transport damage).

5.1 FUNCTIONAL TEST WHEN PUTTING INTO SERVICE FOR THE FIRST TIME

This test is normally carried out only when putting the equipment into service for the first time, but can be repeated whenever required, for example after a repair.

The test shown in Table 5-1 checks the keys and settings on the front panel and the display. It is recommended that the test be executed in the specified sequence. In the case of the Generator Section PSS-16, only level settings are possible. If the PSS-16 is connected as shown in Figure 3-5a or 3-5b and the OP-16 or SPM-16, respectively, is switched on, the green LED for level control above key [4] must light.

5.1.1 CHECK OF CONTROLS AND DISPLAYS

ACTION Key depression or settings	REACTION Level, frequency, LED display
PSS-16	
Switch [12] on back panel dB ⟶ dBm	Level display dBm
p = -20 dBm p_r = -10 dBr (TLP)	Level display: -20 dBm Level display: -20 dBm0; -10.0 dBr
dBm	Level display: -30.0 dBm
Operate the direction keys ⇧ ⇩	Level changes in 10, 1 or 0.1 dB steps. At the level limits, a warning arrow appears with the identification 0 0
p = -24.5 (dBm0)	Level display: -24.5 dBm0 (-10.0 dBr)
BLANK (Hold the key down)	Level is blanked and green LED is extinguished Level display ↓ 0 0

Table 5-1 Sequence of functional test

ACTION Key depression of settings	REACTION Level, frequency, LED display
OP-16	
MEM, 9001, RCL	Instrument switches to standard setup: f = 100.000 kHz, SWEEP TIME = 1 s
f = 12345 kHz f = 6.78 MHz CLR f_{STEP} f_{START} f_{STOP} f_{CENT} Δf	Frequency display: 12 345.000 kHz 6 780.000 kHz 0 1.000 kHz 10.000 kHz 160 000.000 kHz 80 005.000 kHz 159 990.000 kHz
MAN Turn knob [14] MAN Turn knob [14]	LED "FINE" lights Frequency varies in 1 Hz steps LED "COARSE" lights Frequency changes in 100 Hz steps
f = 10 kHz ⇧ STEP ⇩ STEP	Frequency display: 10.000 kHz 11.000 kHz 10.000 kHz
Select all positions of switch [17]	Corresponding LED lights
STEP TIME = 1 s AUTO STEP	LED "STEP" lights. Frequency steps at 1 kHz per second
SWEEP ⟋ SWEEP ⩘ (possibly SWEEP TIME ≥ 10 s)	LED "SWEEP ⟋ " lights. Frequency varies from 10 kHz to 160 MHz or vice versa. Restart by again pressing the key. LED "SWEEP ⩘ " lights. OP-16 sweeps between 10 kHz and 160 MHz
Connect digital voltmeter (DCV) to X output [23]	
f_{START}	DC voltage at X output: -2.5 V ± 50 mV
f_{STOP}	DC voltage at X output: +2.5 V ± 50 mV

Table 5-1 Sequence of functional test (continued)

5.1.2 FREQUENCY CHECK

Connect a digital frequency meter to the fixed level output [44] on the rear of the OP-16 and check that the frequency indicated by the meter agrees approximately with the tuned frequency. Carry out random samples over the whole frequency range.

In order to check the output frequency of the PSS-16 at output [1], connect the Generator Section to the OP-16 or SPM-16 as shown in Figure 3-5a or 3-5b, respectively.

5.1.3 LEVEL CHECK

- Set up a level of 0.0 dB(m) on the Level Generator (see Section 3.4.2.1)
- Output frequency, for example, 100 kHz
- Check the level on the Level Meter (SPM-16: operating mode digital)
- Vary the level with the direction keys and on the Level Meter, check that these level changes are actually produced.

5.1.4 CHECKING THE FREQUENCY RESPONSE

Due to its low intrinsic error, the Milliwatt Power Meter EPM-1 made by Wandel & Goltermann is suitable for this test (error $\leq \pm 0.015$ dB at 75 Ω).

- Set the output level of the PSS-16 to 0 dBm
- Select the reference frequency 20 kHz
- Read off the signal level on the expanded display of the EPM-1 and observe the deviation as the frequency of the Generator is varied. The deviation must lie within the error limits specified in the specifications (taking into account the intrinsic error of the EPM-1)

If the Generator is operated in sweep mode, remember that the EPM-1 has a time constant in the order of 1 s.

Checking the sweep rate:
Reduce the sweep time by one step. Only frequency variations of the Generator which lie within the specified limits may occur.

5.1.5 TOTAL HARMONIC RATIO OF THE OUTPUT SIGNAL

If a spectrum analyser which can measure harmonics in the range up to 480 MHz is available, then the harmonic ratio can be checked. The following values should not be exceed for a_{K2} and a_{K3}:

For $f \leq 100$ MHz..... $\geq$ 40 dB
For $f \leq 10$ kHz to 160 MHz, $p \leq +5$ dBm (-4 dB)..... $\geq$ 34 dB

5.2 O V E R V I E W O F E R R O R N U M B E R S

As shown in Table 5-2, errors in the control sequence and in the operation of the OP-16 are divided into three classes.

Repairs should be carried out only by trained personnel. If a repair is not possible and the unit has to be returned to the factory, it is recommended that the error number be specified in the accompanying papers.

Class	0	Error in control section (not via IEC Bus)
	0-----	No error, indication for test sequence
	0--1-L	RAM error on D0 ... D3
	0--1H-	RAM error on D4 ... D7
	0--1HL	RAM error on D0 ... D3 and D4 ... D7
	0--200	ROM error
Class	1	Hardware error in adder
	1--101	Incorrect addition result
	1--102	Adder does not complete operations
	1--103	DAC = 0 (synthesizer handshake)
	1--104	DAC = 1 (synthesizer handshake)
	1--105	Adder does not start to add
Class	2	Operator errors
	2--001	Invalid address number
	2--002	ROM address: "Store" impossible (fixed frequency or setup from EPROM)
	2--003	Address able to respond only with "Recall" (call up of special programs, see Table 3-6)
	2--004	Start and stop address in different areas. Both must lie either between 0 and 99 or between 200 and the upper ROM address 299
	2--005	---
	2--006	Address not programmed

Table 5-2 Overview of error numbers in OP-16

5.3 MAINTENANCE AND MISCELLANEOUS

The equipment requires no special maintenance provided it is handled correctly. The closed case protects the electronic circuits even during transport. The use of the matching Protective Covers SD-4 for the OP-16 and SD-2 for PSS-16 is recommended in order to protect the front panel controls and the sockets on the rear of the instrument against splash water, dust, and mechanical damage. In addition, the instrument can then be carried with the handle of the protective cover.

For long distance transport or transport under rough conditions, the use of the Transport Container TPK-4 for OP-16 or the Transport Case TPG-4 or TPG-42 is recommended (see Section 5.3.9).

5.3.1 MECHANICAL CONSTRUCTION

Caution: Before opening the instrument, disconnect the mains plug from the supply! Whenever assemblies or options are removed or installed, the unit must be switched off.

The case dimension comply with the DIN standard 41 494 and the American standard ASA C 83.9. The unit can therefore be installed in 19" racks (see Section 5.3.7). The covers, baseplate, and side panels are made of robust cast aluminium.

For servicing purposes, the equipment cover can be removed after loosening the six Allen head cap screws (wrench in accessory box on the rear of the unit) and the complete chassis including the front panel and rear panel can be lifted out of the case. Note that the chassis is connected to the power supply on the right panel of the case via a plug connector.

5.3.2 INSTALLATION OF THE IEC BUS BOARD

a) In PSS-16 (2 boards)

Carefully remove the chassis from the case as described in Section 5.3.1, tip it to the right, and place it with the baseplate vertical.

First install the bus adaptor board [873-F] as follows (see also Figure 5-1).

- Feed the 50 wire flat cable of the board [873-F] from top to bottom behind the level display unit and insert in the corresponding strip socket (if necessary, carefully removing the blue flat cable beforehand).
- Install the chassis in the case.
- Mount the board [873-F] on the chassis with the four screws supplied with the board.
- Insert the universal interface BN 906/01 from the rear in the socket strip of board [873-F] and attach it to the rear of the unit with the two screws supplied with the board.

b) in OP-16

The interface board BN 853/02 is installed from the rear of the OP-16 (see Figure 3-4). After loosening the two outer screws, the plug-in interface board compartment is accessible and the board can be installed (with components side at the top). The interface board is then secured with the two screws.

5.3.3 INSTALLATION OF THE PROM IN THE OP-16

The PROM for the OP-16 (BN 872/00.01) can be ordered and installed later in the OP-16. As the customer-specific data are stored in an MOS memory module (EPROM), installation must be carried out as follows due to the sensitivity of the circuit to static charges.

A general rule for handling MOS components is that tools, workbench, equipment, and user must have the same reference potential.
The MOS component is therefore installed as follows:

1. Switch off the unit.
2. Loosen the six Allen head screws (wrench in the accessory box on the rear) and take off the equipment cover.
3. Hold the instrument (reference potential) with one hand, remove the MOS component from its packing materials with the other hand, holding it at the head), and insert it in the position shown in Figure 5-2. The component is inserted correctly if the marking on the component coincides with that on the socket.
4. Reinstall the instrument's cover and switch on the instrument.

5.3.4 CHANGING FUSES

The equipment fuses are located on the rear of the instrument above the mains plug connector. After removal of the fuse cap, the fuse link can be replaced. The fuse values are printed on the rear of the instrument (see also Section 3.2.1). Replacement fuses are provided in the accessory box on the rear of the instrument.

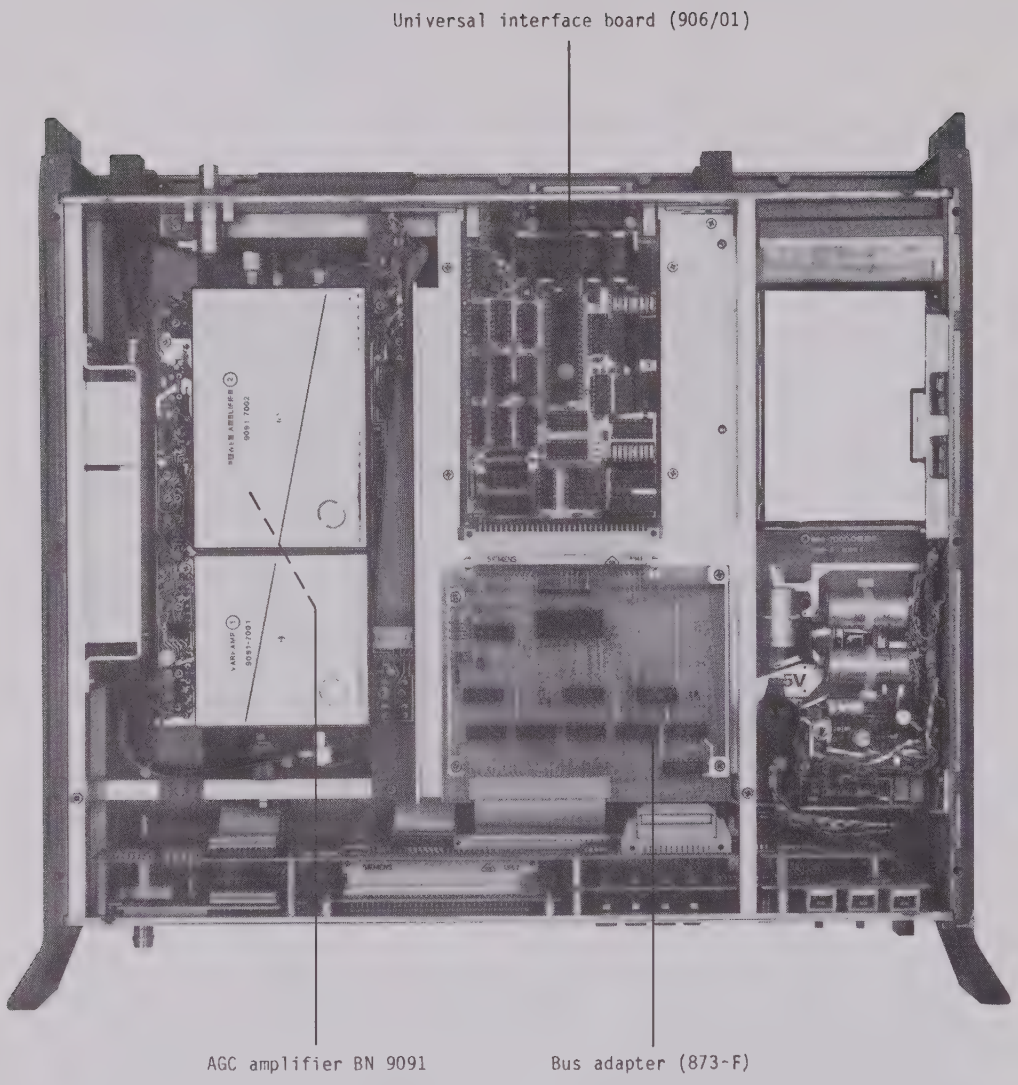


Figure 5-1 Internal view (top) of PSS-16

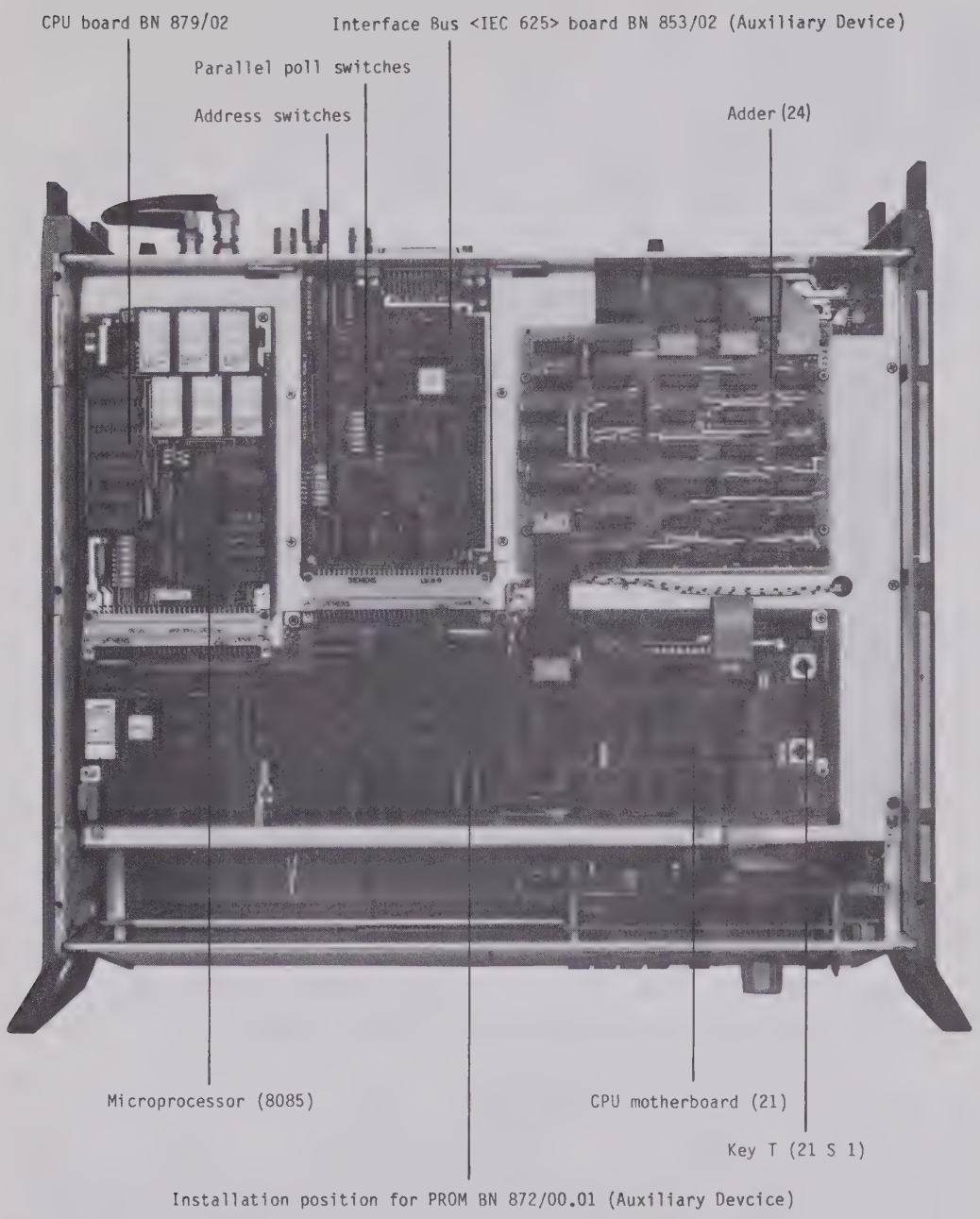

CPU board BN 879/02
Interface Bus <IEC 625> board BN 853/02 (Auxiliary Device)
Parallel poll switches
Address switches
Adder (24)
Microprocessor (8085)
CPU motherboard (21)
Key T (21 S 1)
Installation position for PROM BN 872/00.01 (Auxiliary Devcice)

Figure 5-2 Internal view (top) of OP-16/Control section

5.3.5 STANDBY BATTERIES FOR MEMORY CIRCUITS

The power supply unit on the right side panel of the OP-16 or in the base of the PSS-16 contains rechargeable batteries. These ensure that previously stored values and data are not lost when the power is switched off or if the power supply fails. When the instrument is switched on, the batteries are trickle charged. If the instrument has been switched off for a long period, it is recommended that it be left on for approximately eight hours in order to recharge the batteries.

5.3.5.1 Replacing the Batteries in the PSS-16

Type: 3 NiCd cells 180 mAh (micro), IEC R03

- Turn the PSS-16 over, lay it on its top, and remove the baseplate (lower cover) by unscrewing the six Allen head screws (wrench in accessory box on rear of equipment).
- With the aid of a suitable tool such as a screwdriver, remove the spring clip on the accessible side and take out the batteries.
- Insert the new batteries, observing correct polarity, and replace the spring clip and the baseplate.

5.3.5.2 Replacing the Batteries in the OP-16

Type: 3 Ni Cd cells 180 mAh (micro), IEC R03

- Remove the three Allen head screws on the right side of the upper cover with the aid of the hexagon wrench from the accessory box on the rear of the OP-16.
- Turn the OP-16 over, lay it on its top, remove the six Allen head screws, and take off the cover (baseplate).
- Pull the side wall with the power supply unit upwards out of the case and place it on one side so that batteries are accessible from the top.
- Release the spring clip on the outer edge of the board (844-N) from the holder, if necessary using a tool (such as a screwdriver), and take out the batteries
- Insert the new batteries, observing correct polarity, and replace the spring clip.
- Install the side wall and the baseplate and screw down the top cover

5.3.6 UNIVERSAL SOCKET "VERSACON® 9"

The coaxial output and the connection sockets for control and standard frequencies are equipped with the 75 Ω universal socket "Versacon® 9" made by Wandel & Goltermann (Figure 5-3). This has the advantage that without soldering it permits rapid conversion to one of the connection sockets shown below. The required socket adaptor is screwed into the permanently mounted universal socket with the aid of the mounting wrench (in the accessory box on the rear of the instrument).

Figure 5-3 Basic socket Versacon® 9 with some of the available Versacon® 9 socket adaptors

5.3.7 USE IN 19" RACKS

The case dimensions comply with the DIN Standard 41 494 and the American Standard ASA C 83.9 "Racks and Front Panels". The equipment is therefore suitable for installation in 19" racks, the only necessary conversion being extension of the front panel dimensions by attaching two mounting brackets as shown in Figure 5-4. The complete 19" conversion kit, including mounting screws, is available under the Order No. BN 700/00.04 for the OP-16 or BN 700/00.02 for the PSS-16. Before installation, the rubber feet on the bottom of the equipment and the locating studs on the top of the equipment should be removed (see Figure 5-4).

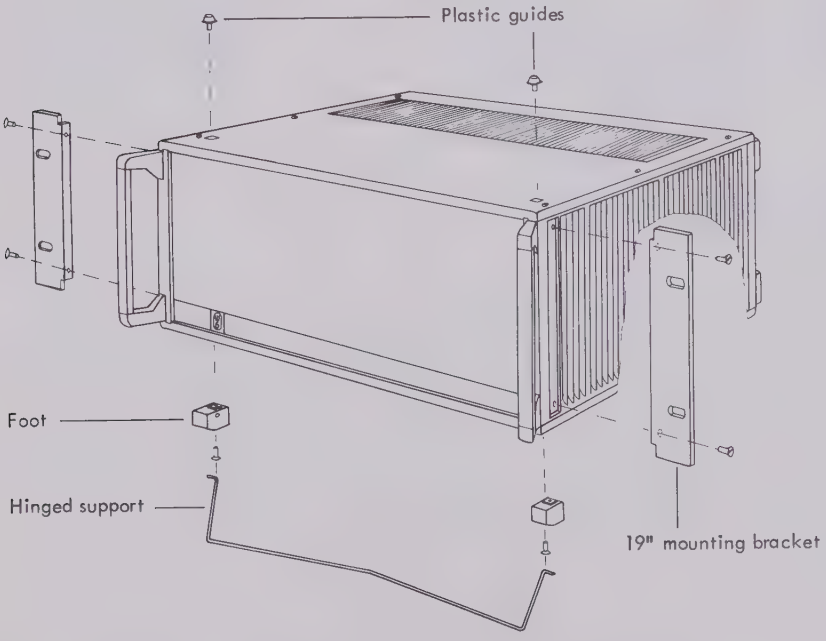


Figure 5-4 Converting the desktop instrument for rack installation

Caution: When installing in equipment cabinets, ensure that the upper limit of the rated range of use of the ambient temperature is not exceeded (see Section 3.1.1). Generally, the following measures are necessary:

A gap of one unit height (44.4 mm) must be provided between the instruments.

If necessary, ventilators (e.g. LTZ-2) must be installed in order to dissipate the heat generated in the cabinet. Suitable air filters should be provided to prevent accumulation of dust in the equipment.

5.3.8 SHIPPING NOTES

Shipping without damage is guaranteed only by correctly designed packing materials. If the original packing materials have been lost, we recommend that the equipment be packed as shown in Figure 5-5.

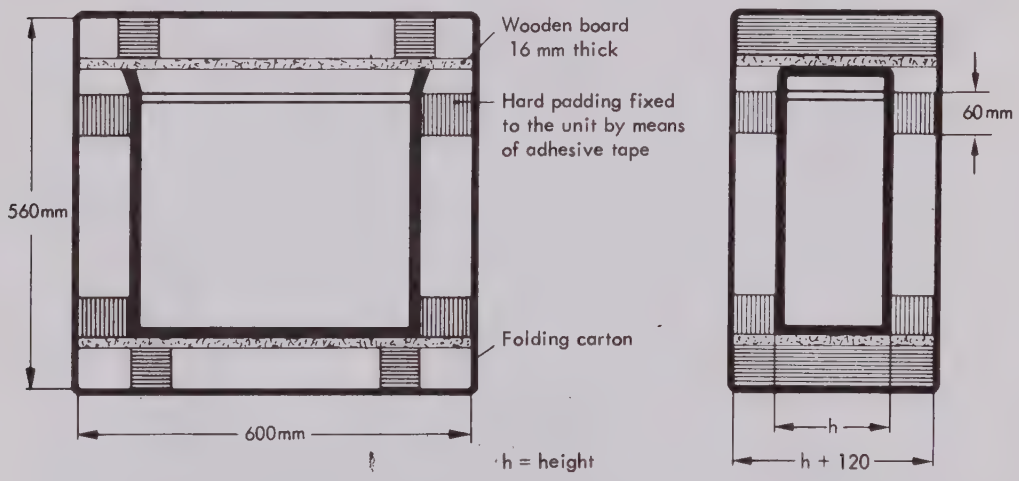


Figure 5-5 Packing instructions

5.3.9 TRANSPORT IN THE EQUIPMENT CASE OR TRANSPORT CASE

The Transport Container TPK-4 for the OP-16 protects the equipment against dust and mechanical damage during light transport (e.g. in a motor vehicle). It also provides protection against splash water. An additional protection of the inclined front panel against impact can be achieved if the Rear Cover SD-4 is placed on the front side of the OP-16 before packing in the transport case. For transport under extreme climatic or mechanical conditions (e.g. rail or air transport), the use of the Transport Case TPG-4 or TPG-42 is recommended, as these protect the OP-16 or PSS-16 against extreme ambient conditions.

Generator Section PSS-16

Operating Information

LEVEL DISPLAY

ABSOLUTE AND REFERRED LEVEL

3 digit display with automatic change of sign when level is set by direction key.
Indication ↓ 00 when Generator is blanked.

For invalid setting, warning arrow and 00 appears.
Display also used as buffer for dBr input.

RELATIVE LEVEL TLP

3 digit display, maximum values ± 69.9 dBr.
Relationship: (a) dBm0 + (b) dBr = (a + b) dBm.

LEVEL SETTING

Level input is carried out by

DIGITAL KEYPAD [2]

Input and setting after depression of the ENTER keys. CLR key clears input in the case of invalid entry. Level is changed by overwriting displayed value.

DIRECTION KEY [5] [6] [7]

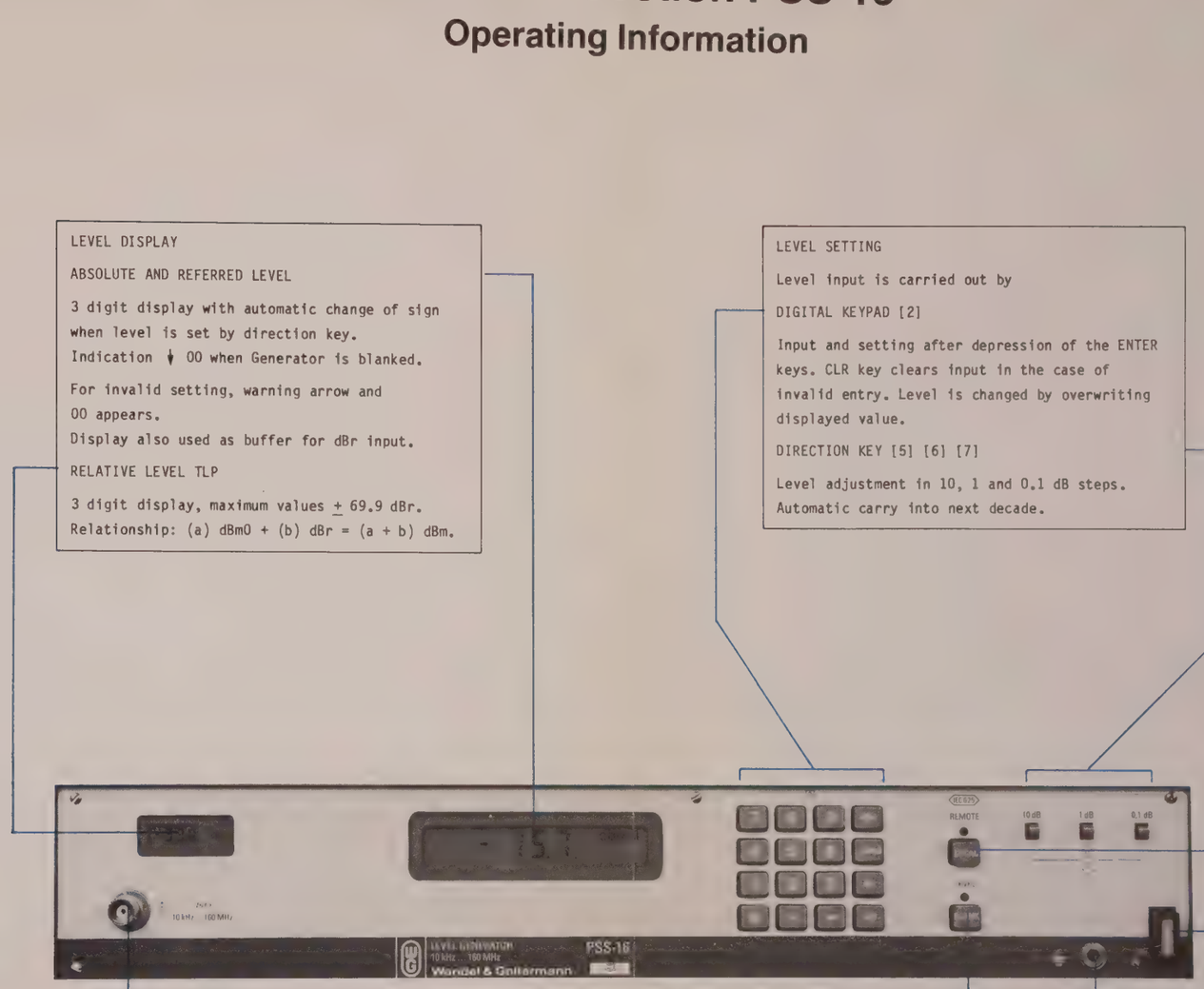
Level adjustment in 10, 1 and 0.1 dB steps.
Automatic carry into next decade.

CONNECTORS ON THE REAR OF THE PSS-16

Mains connector and voltage selection switch with fuse.
Input [11] for output frequency signal from SP-16 or SPM-16.
Control voltage input [13] for external level display, e.g. with EPM-1.
IEC (IEEE) interface.

SWITCHING BETWEEN VOLTAGE AND POWER LEVEL

Switch [12] on rear of PSS-16



REMOTE CONTROL

This LED lights during remote control operations.
All manual controls are inactive.

MAINS SWITCH

Key depressed: PSS-16 on.
Key released: PSS-16 off.

GROUND SOCKET

Socket and case are connected to protective conductor.

OUTPUT [1]

Coaxial, frequency range 10 kHz to 160 MHz
Output impedance 75 Ω
Output level: -69.9 ... +10.0 dB/
-69.9 ... +1.0 dB

GENERATOR BLANKING

Gradual blanking and unblanking.
Output impedance unchanged.

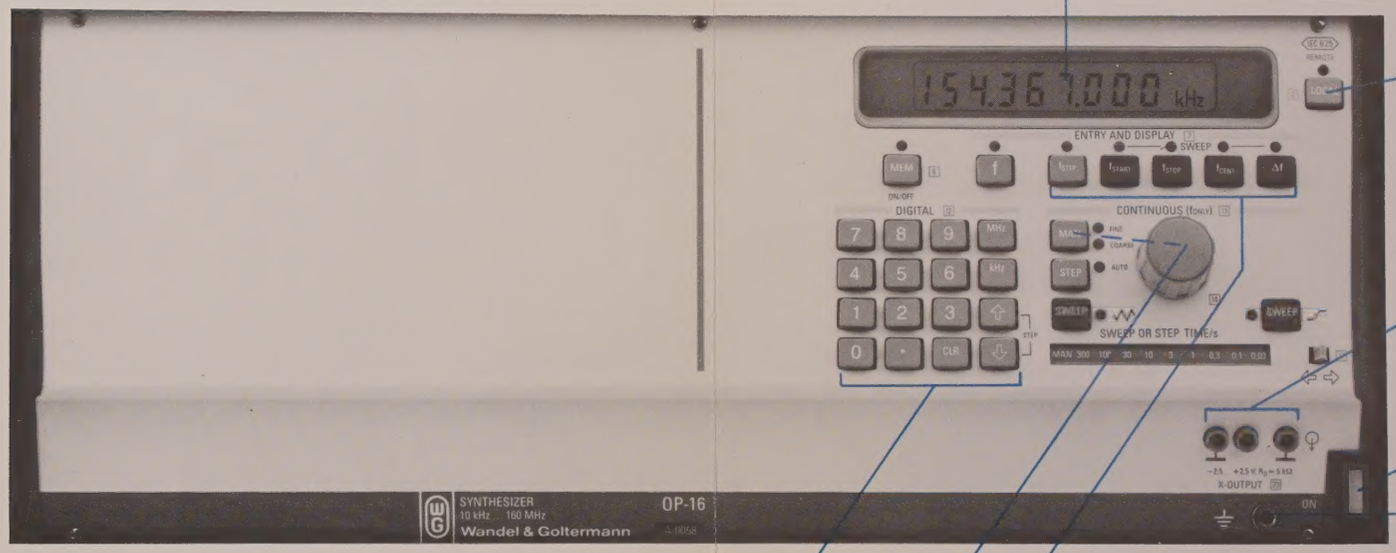
Synthesizer OP-16
Operating Information

CONNECTORS ON REAR OF OP-16

Mains connector and fuse.
Output [42]: Output frequency signal for PSS-16.
Control frequency output [52] and input [45].
Standard frequency output [50] and input [51].
IEC (IEEE) interface.

FREQUENCY DISPLAY

Up to 9 digits.
Resolution 1 Hz for digital tuning [12] or continuous tuning [14] "fine".
Resolution 100 Hz for continuous tuning [14] "coarse".



REMOTE CONTROL [2]

This LED lights during remote control operation.
All manual controls are inactive.

X OUTPUT

DC voltage proportional to frequency deflection during sweep frequency operation.

MAINS SWITCH

Key depressed: OP-16 on.
Key released: OP-16 off.

GROUND SOCKET

Socket and case are connected to the protective conductor.

TUNING

DIGITAL [12]
Input in kHz or MHz via keypad.
Input can be cleared with CLR key if incorrect.
Frequency is changed by overwriting displayed value.

INCREMENTAL
Input of step increment with key f_{STEP}.
Frequency can be incremented or decremented step-by-step with the STEP keys ⇧ ⇩.

CONTINUOUS [17]
MANUAL TUNING
Selection of coarse or fine tuning with the key MAN and frequency tuning with knob.

SWEEP FREQUENCY OPERATION

CONTINUOUS SWEEP
Input of either limit frequencies f_{START}, f_{STOP} or centre frequency f_{CENT} and width Δf.
Initiation with SWEEP key.

INCREMENTAL SWEEP
After input of step width with f_{STEP} and depressing the key AUTO STEP, the OP-16 sweeps step-by-step between f_{START}, f_{STOP}.
Speed depends on selected step times (RATE/S).

SWEEP SEQUENCE
Periodic or single sweep started with SWEEP key.
Deflection times for forward and reverse sweep adjustable. Manual sweep with knob.

INSTRUMENT SHOP

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